...ates
...nt of
...e

...c
...n

Resources
and
Technology
Division

Conservation and Environmental Issues in Agriculture

An Economic Evaluation of Policy Options

David Ervin (Director)
Kenneth Algozin
Marc Carey
Otto Doering
Stephen Frerichs
Ralph Heimlich
Jim Hrubovcak
Kazim Konyar
Ian McCormick
Tim Osborn
Marc Ribaudo
Robbin Shoemaker

This study examines [illegible] l policy approaches to sever[illegible] mental issues. The result[illegible] re proposals or newly approved l[illegible] conservation title [illegible] important respects from the [illegible] is to present analyses of [illegible] l environmental issue[illegible] report findings stress the [illegible] apply to selected conservation and environmental policy options in U.S. agriculture. We hope that those findings may be of use in assessing current and future policy proposals.

Conservation and Environmental Issues in Agriculture: An Economic Evaluation of Policy Options. By David Ervin (Director), Kenneth Algozin, Marc Carey, Otto Doering, Stephen Frerichs, Ralph Heimlich, Jim Hrubovcak, Kazim Konyar, Ian McCormick, Tim Osborn, Marc Ribaudo, and Robbin Shoemaker. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Staff Report No. 9134.

Abstract

Commodity program changes, such as planting flexibility, are estimated to achieve some net aggregate reductions in agrichemical use and erosion, while improving agriculture's market orientation and lowering government cost. However, the potential environmental effects vary widely by region. Although commodity program alteration can lessen some undesirable environmental effects in the short term, it does not remedy the basic externality causes of environmental problems. New land retirement approaches targeted to wetlands restoration and to land use change for water quality and other environmental services can achieve longrun environmental improvement. The net effects of land retirement on environmental quality, food and fiber production, consumer price, and government cost depend on simultaneous commodity program management. Any effects on commodities or the environment ultimately depend also on a host of external conditions (such as trade flows) affecting relative crop prices and input costs.

Keywords: Conservation and environmental policy, planting flexibility, base limitation, wetlands reserve, conservation reserve, commodity program, policy reform, pesticides, fertilizers, soil erosion, water quality, wildlife.

Acknowledgments

The overall evaluation is the product of the entire research group. However, different individuals or teams analyzed specific options and conservation /environmental effects. The list of topics and contributors includes:

- Summary, Introduction, and Notes - Dave Ervin and Otto Doering
- Planting Flexibility - Ian McCormick and Kazim Konyar
- Program Base Limitation - Stephen Frerichs
- Wetlands Reserve - Ralph Heimlich and Kazim Konyar
- Conservation Reserve Program - Tim Osborn and Kazim Konyar
- Surface-Water Quality - Marc Ribaudo
- Ground-water Quality - Ken Algozin
- Wildlife - Marc Carey
- Agricultural Policy Reform - Robbin Shoemaker and Jim Hrubovcak

Several reviewers provided helpful comments on earlier drafts: Kitty Reichelderfer, Alex Barbarika, Sandra Batie, Mike Dicks, Bob Kellogg, Peter Kuch, Bonnie Moore, Clay Ogg, and Jeff Zinn. Mike Price also contributed modeling support in the beginning stages of analysis. Special appreciation is extended to Tiajuana Sizemore and Bridget Struggs for preparation of the manuscript.

Washington, DC 20005-4788 July 1991

Contents

Summary

More attention is devoted to environmental issues in agriculture than ever before. Title XII of the 1985 Food Security Act (FSA) initiated a movement to consistency between agricultural and conservation policies. The Conservation Reserve Program (CRP), Sodbuster, Swampbuster, and Conservation Compliance provisions addressed soil erosion and wetlands protection amid conditions of excess crop supplies, low prices, and farm financial stress. As the 1990's unfold, both the environmental issues and conditions affecting agriculture have changed dramatically, with important implications for policy development.

This report presents a broad economic evaluation of selected agricultural conservation and environmental policy options. We emphasize nontechnical information for a wide audience interested in the policy process. Due to that breadth of coverage, the detailed analytical methods are given in technical appendices or forthcoming reports listed in the references.

The analysis reported here focuses on four current environmental issues:

- o Reducing the potentially adverse effects of agricultural chemicals on ground-water quality,
- o Improving surface-water quality,
- o Restoring agricultural wetlands, and
- o Extending environmental benefits on selected CRP lands.

Most of these issues suffer from a sparse scientific information base characterizing the extent and degree of environmental effects. Nonetheless, policy proposals are surfacing and estimates of potential effects are useful for policy evaluation.

Two basic approaches are investigated: commodity program alterations and forms of land use change or retirement. The principal forces conditioning application of either approach are a healthier agricultural economy, lower crop surpluses, a continuing budget deficit, and international trade negotiations to improve agriculture's market orientation. Economic and environmental effects of selected policy options are evaluated in comparison with baseline conditions characterizing a continuation of 1985 FSA commodity programs.

Since the policy options are not in practice, simulation analyses are used to project probable effects. The estimated production effects assume profit maximizing behavior under recent production costs and predicted crop price changes. Also, agrichemical changes are based on average use levels under existing crop production patterns and may not capture further decreases due to shifts in crop rotations and technology. Thus, the economic and environmental projections should be interpreted as characterizing the direction and general magnitude of effects rather than precise values.

Commodity Policy Alterations

The FSA commodity provisions set agriculture on a path toward greater market orientation to achieve international competitiveness. Target prices and loan rates for program crops were scheduled for gradual decline and program crop yields, to which the support prices apply, were frozen at 1985 levels. If the movement toward market orientation continues to reduce program influence,

divorces price and income support from production decisions, or results in program elimination, the face of agriculture will change. Production of most program supported crops will decrease and their market prices will rise. Nonprogram crop supplies, including soybeans, will increase and their prices will fall. More land will be used as its price falls due to lower government support and the reduction or elimination of land diversions. This land extensification process and market orientation will generally decrease average environmental loadings from agriculture, such as soil erosion and agrichemical leaching, but with widely varying regional effects.

Despite this market-oriented trend, present commodity program rules are still thought to encourage cropping patterns (such as monoculture) that require higher agrichemical use than would occur in their absence. Proposals have thus been introduced to promote wider cropping diversity.

<u>Planting Flexibility</u>

Under the assumed planting flexibility design, farmers would be free to select from a larger set of crops on their farm's base acres in accord with market prices without jeopardizing eligibility for commodity program benefits. Two planting flexibility levels are evaluated: 20 and 100 percent of a farm's base acres with slight variations in land diversion and price support features. Any of the major program crops plus soybeans, hay, or fallow are permitted on the flexible acres with continued income support at present levels.

Major findings include:

- o Changes in the mix and levels of program and nonprogram crops for the 100-percent flexibility case are estimated to decrease overall nitrogen fertilizer and leachable pesticide use in vulnerable situations up to 4 percent, and to reduce aggregate soil erosion producing modest surface water quality benefits.
- o Regional agrichemical effects are not uniform and depend on how production shifts. Areas projected to lose production of program crops show the largest agrichemical decreases, including the Northern and Southern Plains and Lake States regions. Other areas are estimated to increase the production of program crops due to higher relative market prices and thereby increase agrichemical use, such as the Delta and Northeast States. Leachable pesticide and nitrogen use changes can be of different magnitudes and even opposite directions in a region.
- o The 20-percent flexibility case leaves national agrichemical levels virtually unchanged and only slightly decreases aggregate soil erosion.
- o Except for oats, program crop production declines, causing increased prices while nonprogram crop supplies rise, causing decreased prices.
- o Aggregate net farm crop income is projected to stay about even under flexibility. The net income effect includes three possibly offsetting components: commodity program farmers whose market prices rise and government payments fall as program crop prices increase; farmers not participating in programs whose incomes may rise or fall depending upon the proportions of program and nonprogram crops grown; and nonprogram crop producers whose incomes fall from those crops.
- o Government commodity program expenses are projected to decrease by 3 percent for the 20-percent case, up to 30 percent for the 100-percent scenario, and to stay even if deficiency payment rates are held constant at 1990 levels.

- o Estimated production, price, and agrichemical and government cost changes are very sensitive to assumed initial relative crop prices and production costs.

Base Limitation

Another approach to promoting greater cropping diversity is to limit the maximum percentage of a farm's cropland acres to any single program crop. Such a base limitation would be mandatory, unlike the voluntary planting flexibility approach. Three levels of limitation were analyzed: 66, 50, and 33 percent. Analysis results show:

- o Imposing a base limitation principally affects corn, sorghum, and wheat production, mostly in the Plains and Corn Belt regions.
- o While overall pesticide and nitrogen use declines up to 4 or 5 percent for the 33-percent case, national effects on soils highly vulnerable to pesticide leaching are at or near zero.
- o As the limit is tightened, production of nonparticipating corn and wheat is shifted outside the Plains and Corn Belt regions, with consequent increases in leachable pesticide and nitrogen use.
- o National net receipts fall about 2 percent for the tightest restriction, despite rising program crop prices.
- o Suspension of commodity program payments on the limited acres yields estimated deficiency payment savings of about 10, 30, and nearly 60 percent for the 66-, 50-, and 33-percent limitations, respectively.

Establishing an Agricultural Wetland Reserve

The FSA's swampbuster provision is intended to remove government agricultural program incentives to convert wetlands to crop production. Restoring former wetlands that are cropped is another option to contribute to President Bush's "no net loss of wetlands" goal. Wetland habitat is important for endangered species, migratory birds, commercial and sport fisheries, water quality and quantity, flood control, and recreation. Three wetland (restoration) reserve sizes, established through permanent easements, are evaluated: 2.5, 5, and 10 million acres. We analyzed long-term easements because they protect the public restoration investment costs over an extended period.

Evaluation of the wetland restoration programs indicates:

- o Using a least rental cost strategy, enrollments are concentrated in the Lake States and Corn Belt regions with corn, sorghum, and wheat production most affected after price adjustments.
- o Potential environmental benefits are diverse. Increased waterfowl habitat results in annual benefits of $120 million to $440 million (from $48 to $44 per acre) over the 2.5- to 10-million-acre sizes, which equals nearly all existing CRP hunting benefits; surface water quality benefits range from 20 to 76 percent of comparable CRP benefits estimated for current CRP program ($2 to $9 per acre per year); leachable pesticide and nitrogen reductions range up to 2 percent and are concentrated in Lake and Corn Belt States; and flood retardation reduces baseline flood damages by 3 to 17 percent (about $28 per acre annually).
- o Net environmental, production, price, and government cost effects depend upon simultaneous Acreage Reduction Program (ARP) management.
- o If ARP baseline percentages are held constant, corn, sorghum, oats,

wheat, and barley prices increase 5 to 8 percent and soybeans and cotton prices rise about 2 percent for the 10-million-acre reserve. Net farm income without easement payments rises 1 percent.

- Easement costs are estimated to average $223 to $526 per acre for the 2.5- and 10-million-acre programs. Restoration costs total $115 to $155 per acre for the smallest and largest sizes, respectively. Net government costs, composed of easement, restoration, and commodity program savings are estimated to decline for the 2.5- and 5-million-acre sizes, if ARP's are unaltered. Relaxing the ARP's decreases production, price, and government cost adjustments and lowers the total net environmental benefits as former ARP acres return to production.

Extension of Environmental Benefits on Selected CRP Acres

Concern has surfaced that 10-year contracts are insufficient to protect long-term environmental values on some CRP lands. Conservation compliance provisions of the FSA, that would apply to most CRP lands upon return to production, may not be enough to secure continued erosion control on high erosion acres or protect established wildlife habitat or windbreak acres. Additionally, conservation compliance may not even apply to CRP land with filter strips, cropped wetlands, or areas where commodity program participation is low. One approach for protecting CRP values is to extend contracts on these lands for an additional 10 years.

A contract extension program is analyzed and reveals:

- Simulated enrollments are those lands not likely to be protected by conservation compliance or those providing specific environmental values: wildlife habitat (1.5 million acres), filter strips (40,000 acres), field windbreaks (6,000 acres), cropped wetlands (122,000 acres), and extreme erosion (4.5 million acres).
- If contract extensions are acquired in 1990, recent CRP bidding experience suggests an annual rental cost of about $50 per acre, though the longer contract may require a rent premium above that level.
- Effects of the extensions on production, prices, and government costs are not projected due to uncertain commodity program conditions beyond 1996.
- Alternative approaches, such as acquiring easements and permitting limited commercial use not in conflict with environmental values (such as grazing or forage) can lower production decreases and rental cost payments.

Conservation Reserve Program Redirection

National goals for reducing diffuse (nonpoint) agricultural sources of surface-water pollution have not been met. And, enrollment of the 34 million CRP acres to date has been targeted to conserve soil, not to lands producing the most surface-water quality damages. An analysis of a 5- or 10-million-acre 1991-95 CRP expansion beyond 40 million acres aimed at potential surface-water improvements reveals the following effects:

- Shifting the emphasis to surface-water quality shifts new enrollment from the Plains and Mountain regions to the Northeast, Corn Belt, and Lake States regions.
- Annual surface-water quality benefits over the 10-year contract are estimated to average from $24 to $81 per acre for the 5-million-acre

expansion and $18 to $59 per acre for the 10-million-acre expansion. These ranges compare with estimated surface-water quality benefits for the existing CRP of $4 to $12 per acre per year.

- Under a 5-million-acre expansion, estimated effects include an increase in farm income of less than 1 percent, increases in commodity prices of 1 to 5 percent, and a decrease in government outlays for traditional commodity supply control programs of 7 percent. Under a 10-million-acre CRP expansion, farm income rises just over 1 percent, commodity prices increase by 3 to 9 percent, and CCC outlays for traditional supply control programs decline by 14 percent.
- Net environmental, production, price, and government cost effects of the expansion depend on the presumed baseline commodity program operation. For example, government commodity program cost savings from the new enrollments are projected to outweigh annual enrollment costs of about $90 per acre if baseline ARP levels are unaltered. Relaxing the ARP levels can moderate these effects depending upon the relative patterns of new enrollment versus ARP acres returning to production.
- The gains in water quality and other environmental services from the new enrollments must be adjusted for any environmental degradation caused by increased market prices affecting other acres in production.
- Longer term contracts with permitted commercial uses, such as haying and grazing, extend most environmental values in the future at lower program cost and lower overall production and price effects.

Problems in Coordinating Agricultural and Environmental Policies

The analysis reveals that the two policy approaches are not independent. Increasing the CRP enrollment or establishing a wetland reserve ultimately reduces production, raises production costs and crop prices, and increases environmental services, presuming commodity program provisions are unaffected. Likewise, altering commodity program rules to increase planting flexibility yields a set of economic and environmental effects dependent upon land retirement patterns. Because there are an infinite number of policy combinations, the analyses are carried out in relation to a single set of baseline conditions. A critical policy challenge is the selection of commodity and conservation programs to satisfy supply control and environmental objectives simultaneously at an acceptable social cost. Complicating that challenge even further are the effects of unknown external shocks on the supply control, environmental, and cost outcomes. One important lesson is that the environmental performance of commodity program alterations will vary depending upon the nature of those shocks, such as trade shifts.

[illegible] \$35 per acre for the [illegible] [illegible] program [illegible] [illegible] CRP [illegible] \$12 [illegible] per year [illegible] [illegible] [illegible] acres [illegible] [illegible] percent [illegible] [illegible] program [illegible] CRP expansion, [illegible] [illegible] by [illegible] [illegible] per [illegible] price [illegible].

[illegible] environmental [illegible] the expansion depend on the presumed baseline commodity program operation. [illegible] [illegible] the new enrollments are projected to [illegible] [illegible] [illegible] about [illegible] [illegible] the [illegible] program [illegible] the gains in water quality [illegible] [illegible] caused by [illegible] [illegible] program cost and lower overall [illegible] and price effects.

[illegible] in Conservation [illegible] and Commodity Program [illegible]

[illegible] reveals that [illegible] [illegible] the CRP [illegible] production [illegible] [illegible] [illegible] [illegible] altering [illegible] [illegible] flexibility [illegible] [illegible] [illegible] there are [illegible] [illegible] the analyses are [illegible] a single [illegible] [illegible] [illegible] [illegible] [illegible] objectives [illegible] [illegible] acceptable social cost [illegible] [illegible] [illegible] [illegible] depending upon the nature of those shocks [illegible]

[illegible] [illegible] of [illegible] [illegible] of [illegible] [illegible] [illegible]

[illegible] [illegible] regions in the Northeast, [illegible]

[illegible] water quality benefits over the 10 [illegible] [illegible] from \$[illegible] to \$[illegible] per [illegible]

Conservation and Environmental Issues in Agriculture

An Economic Evaluation of Policy Options

David Ervin (Director)
Kenneth Algozin
Marc Carey
Otto Doering
Stephen Frerichs
Ralph Heimlich
Jim Hrubovcak
Kazim Konyar
Ian McCormick
Tim Osborn
Marc Ribaudo
Robbin Shoemaker

Introduction

Title XII of the 1985 Food Security Act (FSA) was a fundamental change from past legislation. Major conservation provisions were integrated with commodity programs and given title status in the farm bill. The Conservation Reserve Program (CRP) and Conservation Compliance, Sodbuster, and Swampbuster provisions addressed soil erosion and wetlands conversion problems amid conditions of excess crop supplies, low prices, and farm financial stress. Forces influencing construction of new conservation and environmental legislation in agriculture, however, have changed dramatically since 1985.

Agriculture's overall economic health is much improved and market prices have strengthened, while costly crop surpluses have declined. Pressure to cut the Federal budget deficit is stronger. The focus of resource management problems has shifted from primarily soil conservation to multiple environmental quality concerns. And, compared with soil erosion, a smaller scientific information base is available to characterize the extent and degree of these new environmental problems. Finally, pressure is being exerted to reform commodity policies toward a greater market orientation for domestic budget, international trade, and environmental reasons.

Although multiple conservation and environmental issues and proposals compete for attention, a predominant theme runs through virtually all: the reduction of adverse effects of agrichemical use. Clearly, potential ground- and surface-water quality problems due to fertilizers, pesticides, animal waste, and sediment have surpassed concern about future production losses due to soil erosion. Related to water quality but also to food safety, considerable interest has been expressed in sustainable agriculture systems characterized principally by reduced agrichemical use. Measures to alter commodity programs and possibly achieve wider cropping diversity with lower fertilizer and pesticide use, such as increased planting flexibility, have been introduced. An expanded and redirected CRP to achieve water quality improvements has been proposed. Perhaps the only issue not linked directly to agrichemical concerns is the restoration of wetlands from crop uses.

Selection of Policy Options

This report summarizes an aggregate economic evaluation of selected conservation and environmental policy options. The options pertain to four current issues in agriculture.

- o Reducing the potentially adverse effects of agricultural chemicals on ground-water quality,
- o Improving surface-water quality,
- o Restoring agricultural wetlands, and
- o Extending environmental benefits on selected CRP lands.

We compare the projected economic and environmental effects of each option relative to conditions expected if the 1985 FSA provisions continue.

Generally, the approaches are commodity program alterations or forms of land retirement. Table 1 summarizes the key features of the various options in the order to be discussed. The first option, planting flexibility, is to permit the planting of a range of crops on lands participating in specified Federal commodity programs rather than just one program crop. Participating producers could respond to market prices of program and nonprogram crops on some percentage of their base acres. An important environmental goal of planting flexibility is greater cropping diversity and rotation opportunities which are presumed to reduce agrichemical applications. For example, corn rootworm

Table 1 -- Summary of key features of selected policy options for conservation and environmental issues in agriculture

Policy option	Basic mechanism	Duration	Potential conservation and environmental objectives
Planting flexibility: 20 percent 100 percent	Permit a wider range of crops to be planted on specific commodity program acres	1991-95	Agrichemical use Soil erosion
Base limitation: 66 percent 50 percent 33 percent	Limit the maximum percentage of a farm's commodity program acres in any specific crop	1991-95	Agrichemical use Soil erosion
Wetland reserve: 2.5 million acres 5 million acres	Purchase permanent easements on eligible cropped wetlands to restore wetland status	Enrollment 1991-95 Easements 1991-permanent	Restore cropped wetlands to provide varied conservation and environmental services, such as wildlife habitat and flood control.
Conservation Reserve Program: Contract extension	Negotiate contract extensions through a bidding process for specific lands	1996-2005 or beyond	Protect specific conservation/ environmental values beyond 10-year contracts, such as wetlands and stream buffer strips
Program expansion: 5 million acres 10 million acres	Solicit bids for contracts on specific acres related to surface-water quality problems	Enrollment 1991-95 Contracts 10-15 years	Enroll new acres targeted to surface-water quality improvements

insecticide treatments can often be eliminated if the corn is rotated with another crop.

A second approach is to restrict the maximum percentage of a participating farm's program base acres to any specific program crop to avoid monoculture. The planting flexibility and base limitation approaches share the goals of promoting wider crop mixes and reduced agrichemical use, both of which are consistent with sustainable agriculture precepts.

The third instrument is the creation of a national wetland reserve through the voluntary acquisition of permanent easements on cropped wetlands. This wetland restoration initiative would be implemented over a 5-year period and could be oriented to acres producing the most important wetland services.

The fourth option covers the CRP. One part is the possible extension of contracts beyond 10 years to protect specific environmental values on those acres. The extensions would be voluntary and could permit commercial uses (such as trees or forage) that do not diminish the environmental values appreciably. Another possible CRP initiative is a redirection/expansion beyond the 40-million-acre goal, targeted toward surface-water quality improvement. 5- and 10-million-acre expansions targeted to surface-water quality improvements are investigated under continuation of the general CRP operating procedures.

Analytical Procedures

A brief explanation of general study procedures is necessary to interpret the findings. Given the considerable scientific uncertainty surrounding many of the perceived environmental issues, a complete economic evaluation with estimated monetary benefits and costs is impossible. Rather, the study estimates economic values for aggregate conservation, environmental, production, price, and other effects where data and methods permit, and describes quantitative or qualitative adjustments in variables not amenable to economic assessment.

With those potential effects, tradeoffs among effect variables are characterized. Results usually pertain to average annual effects during the 1991-95 period except when programs are implemented over longer periods. Therefore, the estimates do not portray full longrun adjustments. Also, the effects are reported in current dollars and are not discounted to ease interpretation. The focus is broad at the national level, but regional effects are also described where important adjustments may occur. All estimated effects are relative to projected base conditions characterizing a continuation of the FSA commodity and conservation provisions.

Policy Option Evaluation

Each of the policy options--planting flexibility, program base limitation, wetland reserve, and conservation reserve program modifications--is subjected to empirical analysis to assess aggregate economic and environmental effects.

Increased Planting Flexibility

Planting flexibility addresses the concern that current commodity programs

distort production decisions leading to inefficiencies in resource allocation. The problem stems partly from current income supports that link support payments, both present and future, to the production of program crops. While land diversion requirements mitigate this to a certain extent, Federal commodity programs encourage the production of a restricted set of crops, and discourage crop rotations.

Although the concept of planting flexibility is generally perceived as beneficial to the sector's efficiency (Agricultural Policy Working Group, 1989)1/, environmental improvements will depend on a number of factors. Increased flexibility can potentially benefit the environment in the cases: (1) where crop mixes are altered to include larger percentages of crops associated with less erosive and less chemically intensive production practices, or (2) where alternative production practices, such as rotations, requiring fewer pesticides and inorganic fertilizers, are adopted to produce this set of crops.

While planting flexibility will relax some of the potential barriers to these movements, the provision in itself does not guarantee environmentally beneficial changes in cropping practices. Only if production practice modifications occur in areas where resources are susceptible to chemical or erosion damage will planting flexibility produce beneficial environmental effects.

Background

It is argued that Federal commodity programs affect production practices and subsequently environmental conditions through three alleged linkages: mix, scale, and intensity (Miranowski, 1975). First, commodity-specific price supports inflate prices and reduce price risk relative to nonprogram crop production, increasing the economic attractiveness of those commodities. The resulting higher per acre net returns tend to favor program crop production over nonprogram crops, influencing the mix of crops in production.

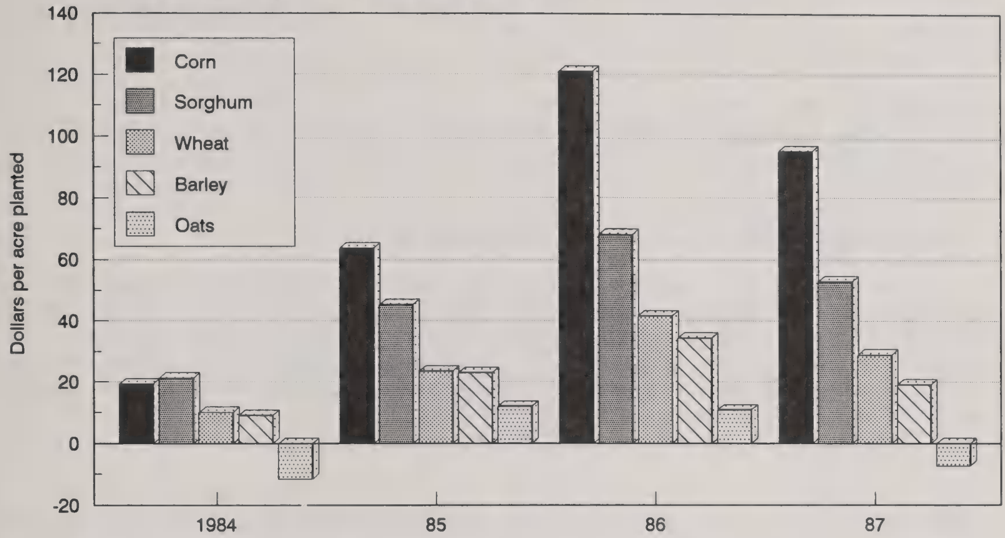
Similarly, differential supports among program crops can favor the production of one program crop over another, leading to a concentration of production in the most highly supported crops. Importantly, the most highly supported crops are often associated with production practices that are more erosive and more reliant on agrichemicals than many nonprogram crops (Reichelderfer, 1985).

Figures 1 and 2 illustrate the value added to per acre production for participants and the associated participation trends for the five major grain commodity programs from 1984 through 1987. The figures demonstrate the rising trend in participation as relative benefits increase. For example, the corn program, with the largest per acre subsidies, maintained the highest participation rates throughout the period.

Second, higher and more stable prices for supported crops draw additional acres into production, increasing the scale of agriculture. Increasing the scale of agriculture adds to erosion risk and increases the risk of chemical leaching.

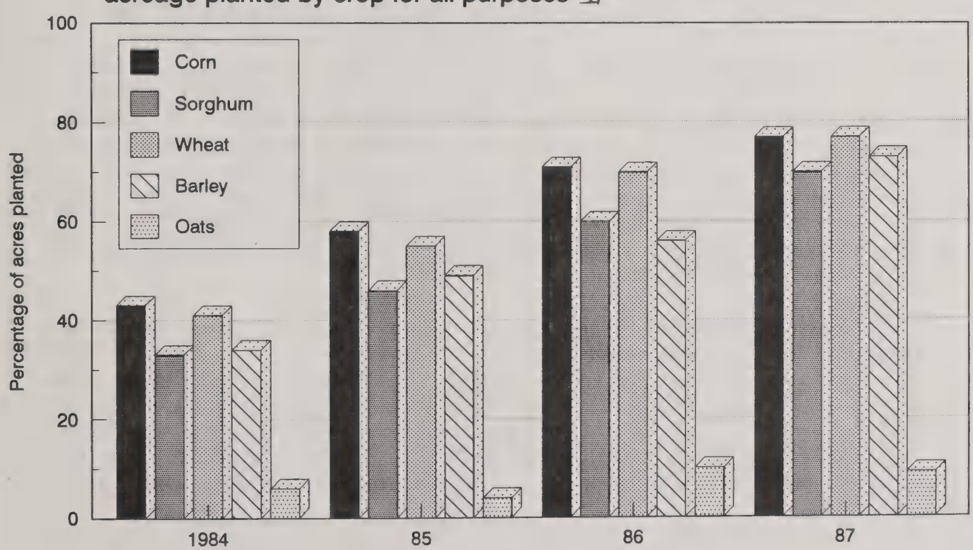
1/ See reference section.

Figure 1 -- Estimated national average value of participating in commodity programs for selected crops 1/



1/ The value of participation represents the per planted acre value of deficiency payments minus the opportunity cost of withholding land from production.

Figure 2 -- Program participation as a percentage of national acreage planted by crop for all purposes 1/



1/Participation rates reflect the number of planted acres complying with commodity program provisions relative to the total number of acres planted.

Finally, crop selection limitations that affect a participant's access to future income support and risk management decisions may indirectly influence the intensity of production practices. On farms where producers have accumulated a large percentage of crop acreage base relative to arable cropland, the maintenance of base may impede annual rotation practices that can reduce chemical fertilizer and/or pesticide requirements (Powell, 1987; Tisdale and others, 1985).

In essence, current commodity program provisions affect the relative profitability of different crops. This leads to production and resource allocation patterns that can exacerbate agriculture's effects on the environment.

Incorporating Flexibility - Past and Present

One alternative to the rigidity of current programs is planting flexibility. The concept offers program participants the opportunity to choose from a wider range of crops that can be produced on a portion or all of their program acreage. Under planting flexibility, participating farmers would face market prices for cropping decisions rather than program payment levels. And, unlike current commodity program provisions, crop choice will not affect eligibility for income support payments or the base acreage eligible for support.

Farmers' responses to market conditions may result in cropping patterns and production practices that do not stress the environment to the same extent as current patterns and practices. Potential outcomes include less monoculture, a different rotation of program crops, or a different monoculture or rotation including nonprogram crops previously unattractive given the high support levels for program crops. Such changes can result in reductions in agrichemical use and soil erosion.

Although planting flexibility is a departure from 1985 commodity program provisions, the concept is neither new nor untried. For example, the Food and Agricultural Act of 1977 reauthorized a land retirement and support payment system based on current plantings rather than historic acreage histories. Commonly referred to as Normal Crop Acreage (NCA), this program enabled participating farmers to choose from a wide variety of crops. A general assessment of the NCA by the Congressional Research Service indicates that farmers appear to have taken advantage of the increased planting flexibility (Ek, 1989). However, the report goes on to suggest that due to the continued reliance on crop selection to determine support payment levels, the 1977 NCA structure eliminated market signal distortions only in cases where market price rose above target prices.

More recently, commodity programs have incorporated a number of production alternatives for participating producers. The 50-92 and the later 0-92 provisions allow operators to substitute a conservation cover for program crops (but not harvest the cover), while maintaining deficiency payments on 92 percent of the permitted acreage and protecting program acreage histories. In 1987, approximately 8.9 million acres took advantage of this program (U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, 1988).

Additional flexibility has been added to the 1989 and 1990 programs to meet the growing demand for oats and a loss in the U.S. market share in oilseeds. These amendments permit program participants to substitute oats, soybeans, and

sunflowers on a portion of their program acreage without base acreage penalty. However, participants will not receive deficiency payments on acreage they plant to alternative crops.

Analytical Procedures

The analysis presented here attempts to answer four questions concerning increased planting flexibility:

(1) What are the implications for production patterns and chemical use?
(2) What are the environmental implications in terms of potential chemical leaching and erosion?
(3) What are the economic tradeoffs in terms of farm income and the budget?
(4) How will variations in implementation design influence these results?

Four scenarios were chosen to illustrate the sensitivity to variations in 1) the degree of flexibility granted participants (20 percent or 100 percent), 2) land diversion requirements (crop specific or generic ARP's), and 3) income support levels (deficiency parents frozen at 1990 levels or based on market prices). Table 2 provides a label for each scenario and definition. The analysis includes all program crops and nonprogram crops of soybeans, hay, and fallow. To address these questions, the analysis progressed through a series of stages.

First, a programming model covering the 10 major farm production regions and 9 major crops is used to capture the effects of planting flexibility on

Table 2 -- Assumed planting flexibility scernario: labels and definitions

Scenario label	Eligible acreage	Land diversion requirement	Price/income support design
F20A	20% of crop acreage base	Crop specific 1990 ARP rates applied to flexible and non-flexible program acreage	Continued for all acreage based on historical acreage and yields 1/
F100A-P	100% of crop acreage base	Crop specific 1990 ARP rates applied to flexible and non-flexible program acreage	Continued for all acreage based on historical acreage and yields 1/
F100G-P	100% of crop acreage base	Generic 10 percent applied to historic program acreage	Continued for all acreage based on historical acreage and yields 1/
F100A-FP	100% of crop acreage base	Crop specific 1990 ARP rates applied to flexible and non-flexible program acreage	Continued for all acreage based on historical acreage and yields 2/

1/ Deficiency payment rates vary as market prices move.
2/ Deficiency payment rates remain frozen at 1990 levels.

production patterns, chemical use, commodity prices, farm income, and the budget (app. 1). The results are compared with a baseline developed to represent the 1990 crop year and are presented as percentage changes from the base year. The effects on cropping patterns, crop prices, farm income, and the budget should be interpreted as values after the sector adjusts to changes in program design within 1991-95.

Estimated effects of planting flexibility on chemical leaching potential, erosion, and surface-water quality are derived from changes in the number of acres in production, the allocation of that acreage among the available crops, and the location of these practices relative to environmentally sensitive areas. Descriptions of the models used to estimate these potential effects on erosion/surface water and ground water are included in appendices 2 and 3, respectively.

Results

Analysis results are presented for acreage and production shifts, crop mix, fertilizer and pesticide use, chemical leaching potential, erosion and surface-water quality, and farm income and budget effects.

Acreage and Production Shifts. Figure 3 shows the effects of the planting flexibility scenarios on national harvested acreage by crop. Under all scenarios, program acreage declines because market prices replace support prices as the effective price for planting decisions. Note that the scenario with frozen deficiency payment levels (F100A-FP) does not yield different production levels than the F100A-P case, so only the F100A-P scenario result is given. Overall declines in program crop plantings are partially offset by an increase in soybeans and hay acreage (fig. 4). Net declines in harvested acreage range from less than 1 percent for 20-percent planting flexibility to 3 percent for 100-percent flexibility with a generic land diversion requirement.

Aggregate production declines as acreage decreases. However, the percentage decrease in production is smaller, compared with the decrease in acreage, reflecting movements away from the least productive lands. Corn production is an exception in this regard. The higher decline in acreage compared with production reflects regional shifts toward areas where corn has lower yields, but becomes relatively profitable under rising market prices. Nonprogram crop production increases proportionately less than acreage, indicating a shift toward less productive acreage previously allocated to program crop production.

Market prices move inversely to production, rising as program crop production falls and falling slightly as nonprogram production increases. Rising prices more than offset the acreage declines, resulting in an overall increase in the value of production (fig. 4). Increases in the total value of production for the crops considered in this analysis range from less than 1 percent for the 20-percent scenario to more than 4 percent for each of the 100-percent scenarios.

Crop Mix. Harvested acreage for program crops generally declines, most notably for corn, sorghum, and wheat (fig. 3). These are the most highly subsidized crops (fig. 1). As the effective prices for program crops decline, nonprogram crop acreage (hay and soybeans) and fallowing increases.

Figure 3 – Estimated effects of planting flexibility scenarios on harvested acreage

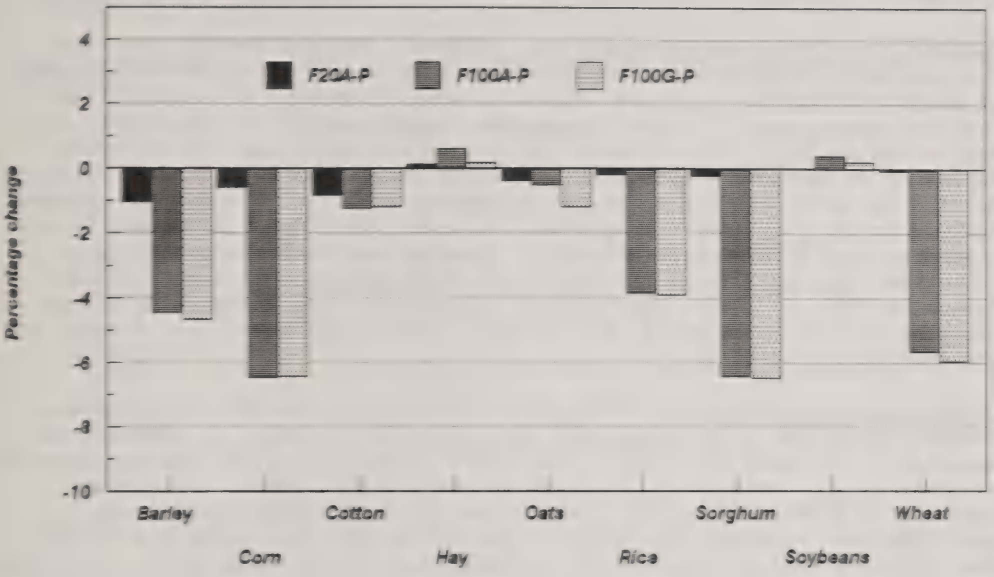


Figure 4 – Estimated effects of planting flexibility scenarios on harvested acreage and value of production

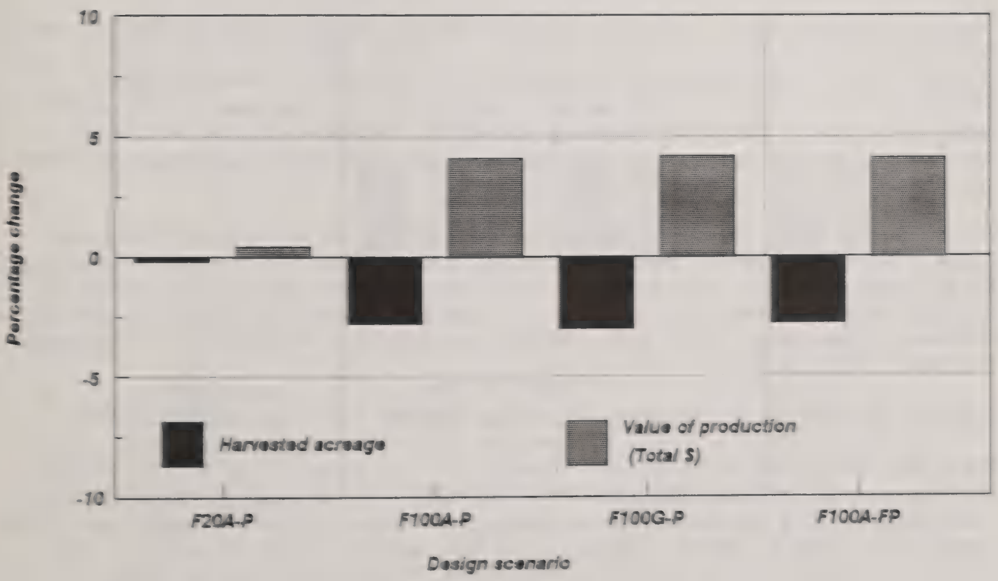


Table 3 illustrates the shift in the aggregate crop mix for each of the four scenarios. In all cases, the ratio of nonprogram to program crop acreage and the ratio of oats (the least supported crop) to the more supported crops (corn, sorghum, wheat, and barley) acreage increases and the range is from less than 1 percent to 6 percent.

Chemical Fertilizer and Pesticide Use. Figure 5 depicts the effects of the four scenarios on fertilizer and pesticide use. Declines in the total number of acres treated, combined with shifts in crop mix toward crops with lower per acre use rates, result in declines in the total quantity of fertilizers and pesticides applied. The estimated effects on aggregate use slightly vary depending on implementation design. Changes range from less than a 1-percent decline for pesticide use under the 20-percent scenario to a nearly 4-percent decline in the pounds of nitrogen applied under the 100-percent scenario with a generic land diversion requirement. Chemical use declines to a greater extent as flexible acreage increases and slightly more with a generic land diversion (fig. 5). Note that changes in input use are due only to changes in cropping patterns, locations, and acreage. The analysis does not account for possible input substitution.

Chemical Leaching Potential. The effect of planting flexibility on chemical leaching potential is influenced by three factors: changes in chemical use associated with crop mix shifts, the number of acres treated, and the location of those effects relative to those areas where the potential for chemical leaching is greatest (app. 3). Reductions in aggregate fertilizer and pesticide use, stemming from cropping pattern shifts, are estimated to reduce the risk of nitrogen and pesticide leaching nationally, ranging from less than 1 percent for the 20-percent flexibility scenario, to roughly 4 percent for both 100-percent scenarios (fig. 6). As explained in appendix 3, the reported changes in pesticide leaching pertain only to the soils and pesticide leaching combinations between high and medium classes rather than all changes. This methodology of focusing only on the conditions most likely to generate physical leaching is also carried through to the other options.

Regional effects vary. Nitrogen leaching potential declines in the Southeast, Lake States, Corn Belt, Northern Plains, Southern Plains, the Mountains, and the Pacific. Those decreases coincide with increases in the relative percentage of hay and soybean acres, combined with a decrease in the number of acres harvested. Nitrogen leaching potential increases in the Northeast, Appalachia, and Delta, reflecting increases in program crop acreage in these regions.

Pesticide leaching potential is estimated to fall in the Appalachian, Lake States, Northern Plains, Southern Plains, and the Pacific regions, resulting from cropping shifts toward crops with lower per acre application rates of highly leachable chemicals. Pesticide leaching potential increases in the Northeast, Southeast, Corn Belt, Delta, and Mountain regions, again reflecting increased program acres.

The variability of the regional cropping pattern and leaching potential effects results from a number of factors not evident in the national analysis. These are described in detail in appendix 3. In general, as market prices replace support prices, the relative profitability of program crops declines. This results in a movement toward nonprogram crops and lesser supported crops nationally (such as oats). However, as the market prices of program crops increase in response to production declines, these crops become more

Table 3 -- Estimated shifts in national crop mix under planting flexibility scenarios

Implementation design	Ratio of non-program to all crop acreage	Ratio of nonprogram to program crop acreage	Ratio of oats to highly supported crop acreage
		Percent change	
F20A-P	Less than 1	Less than 1	Less than 1
F100A-P	3.4	6.3	5.8
F100G-P	3.3	6.0	5.2
F100A-FP	3.4	6.3	5.8

Figure 5 -- Estimated effect on fertilizer and pesticide quantities of planting flexibility scenarios

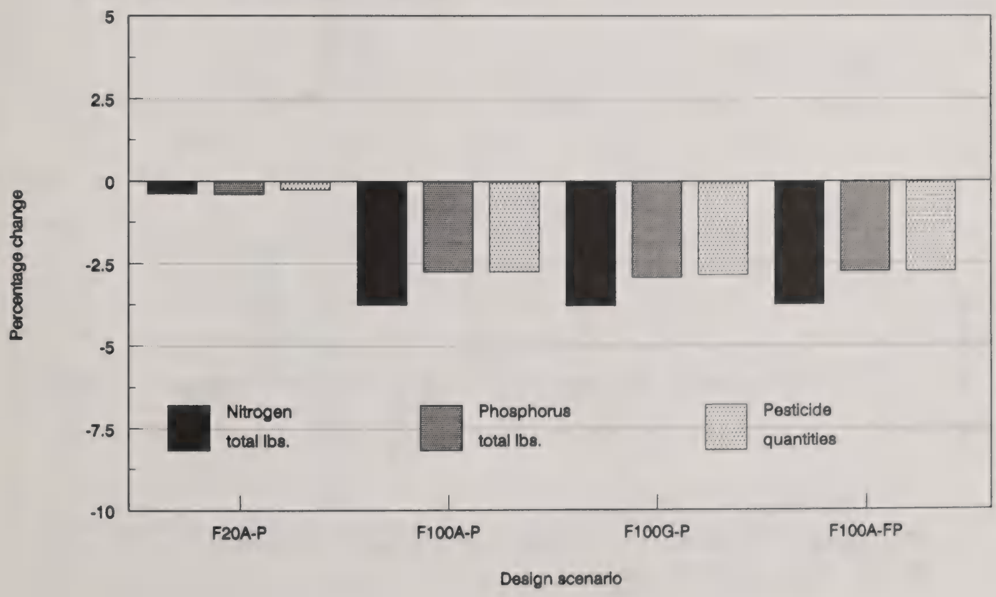
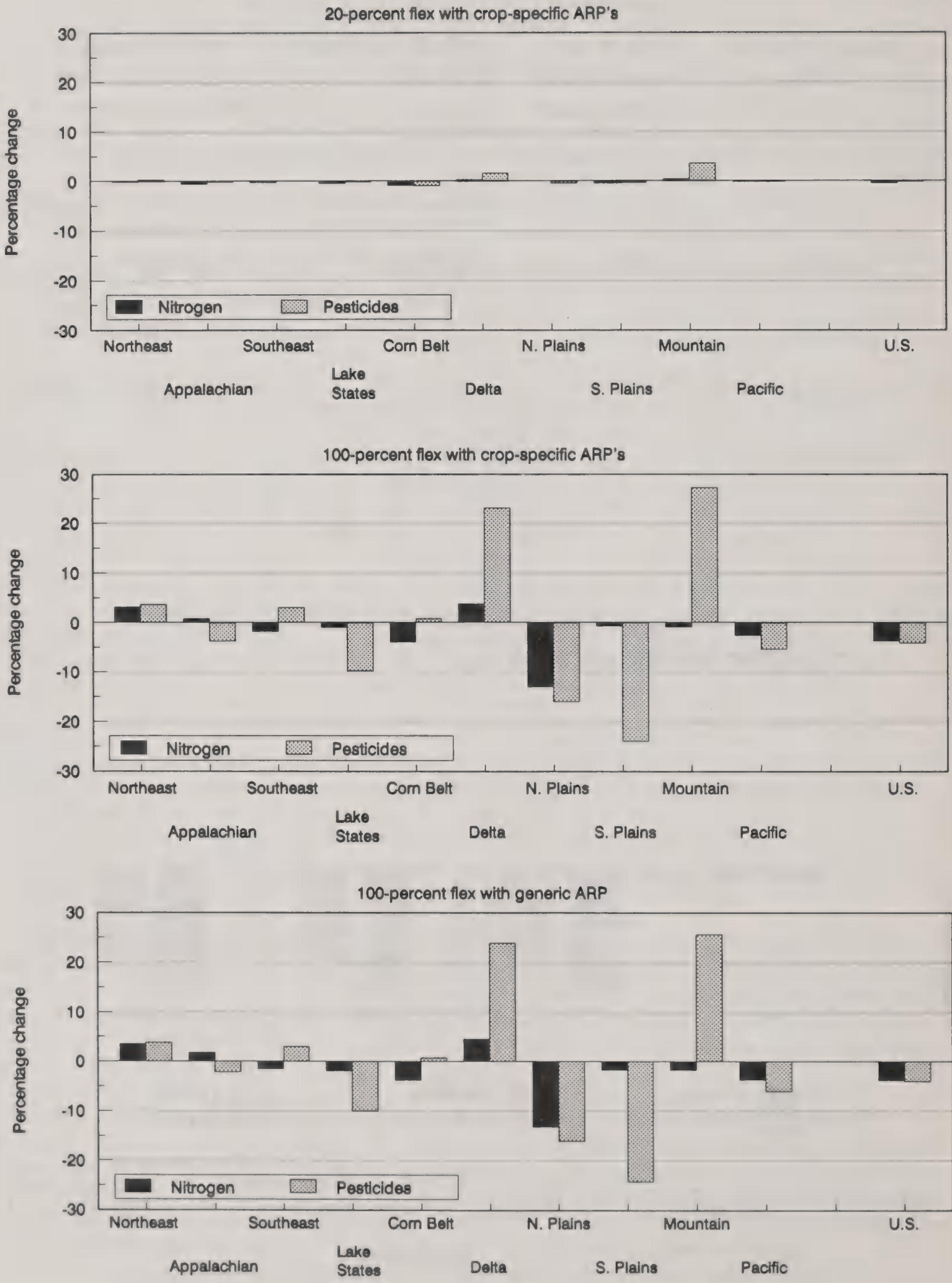


Figure 6 -- Estimated regional effects of planting flexibility scenarios on pesticide and nitrogen leaching potential



attractive to nonprogram producers. In regions where these crops now become the most profitable alternative, their acreage increases. For example, in the Southeast, one of the regions most vulnerable to chemical leaching, the relative percentage of corn increases in response to an increase in relative profitability. However, the average application rates and the leachability of the chemical mix associated with corn in the Southeast is higher than those for the crops which corn displaces (primarily wheat and sorghum). The combination of these factors results in an overall increase in pesticide leaching potential in the Southeast, even though national, overall pesticide leaching potential declines.

Erosion and Surface-Water Quality. The shifts in cropping patterns are estimated to affect both erosion and agrichemical applications. The 20-percent flexibility option reduces net national erosion insignificantly on land in program crops.2/ However, erosion increased slightly in the Delta due to increased acreage in more erodible crops, such as soybeans and corn. Net surface-water benefits from reduced erosion are estimated to range from $3 million to $9 million per year, with the largest increases in the Appalachian and Corn Belt regions (table 4). The width of the range reflects uncertainty in valuing surface-water quality gains. Total planting flexibility resulted in appreciably larger erosion reductions and net annual benefits range from $13 million to $53 million. The largest beneficiaries are the Northern Plains and Lake States, while those experiencing the biggest losses are the Delta and Northeast States.

Farm Income and the Budget. While environmental concerns are of principal interest here, it is important to consider the potential tradeoffs in terms of farm income and the budget. Figure 7 illustrates the estimated effects of planting flexibility on national farm income and direct government outlays (deficiency payments) and the sensitivity of these effects to changes in implementation design. The results indicate that increased crop selection flexibility will have a positive effect on farm income, while either reducing direct government expenditures or maintaining them at the 1990 level. The magnitude of farm income growth varies with implementation design, increasing from less than 1 percent to just over 10 percent. When deficiency payment rates are fixed, direct expenditures decline as participating farmers move toward nonprogram crops and less supported commodities, causing income support to decline.

Interpretation

The effects of increased planting flexibility vary with implementation design. While the directions of these effects remain consistent overall, the magnitudes differ. Increasing the number of acres eligible for the planting flexibility option is estimated to strengthen the acreage allocation response as more acreage is exposed to market price signals for wider crop selection. Larger acreage and crop mix response translates to larger declines in chemical use, amplifying the potential environmental benefits in terms of chemical leaching potential, erosion, and surface-water quality. Since land diversion represents a cost to producers, differential diversion rates (F100A-P) tend to

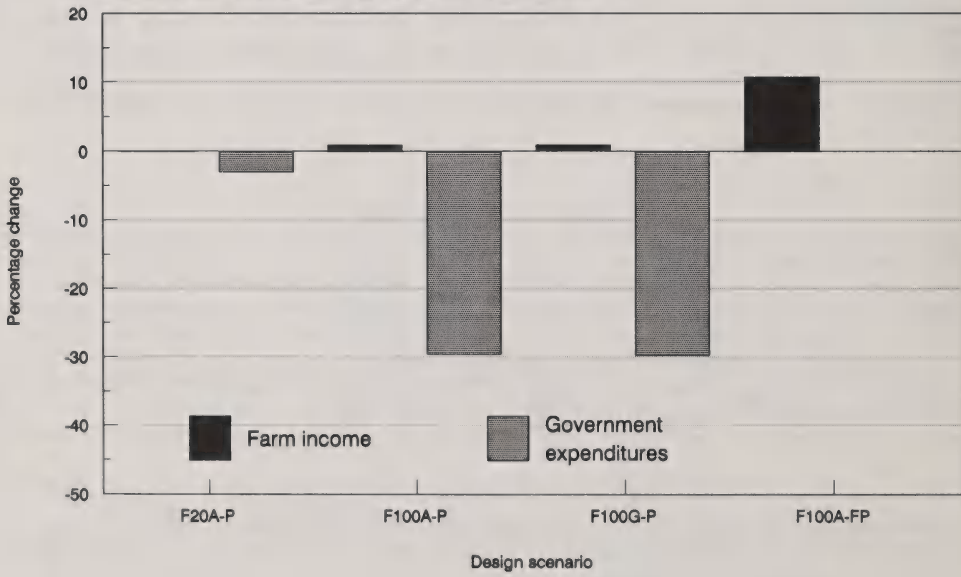
---

2/ Estimates of erosion changes on land growing nonprogram crops are not included due to data deficiencies. This should not represent a large error, since 80 percent of erosion is estimated to occur on program acres, based on National Resources Inventory data.

Table 4—Estimated annual average surface-water quality benefits under planting flexibility

Regions	F20A		F100A		F100G	
	Low	High	Low	High	Low	High
	Million dollars					
Northeast	0.5	1.8	-1.4	-4.5	-2.1	-7.0
Appalachian	.6	1.7	-.6	-1.7	-.5	-1.3
Southeast	.4	.8	.4	1.0	.4	1.0
Lake States	.2	.7	7.3	22.0	7.8	23.6
Corn Belt	.9	3.3	.1	.4	-.2	-.6
Delta States	-.3	-1.5	-6.5	-35.8	-7.4	-40.7
Northern Plains	.1	.5	6.3	50.1	6.4	50.3
Southern Plains	.2	.7	2.4	8.3	2.9	9.8
Mountain States	.1	.3	2.6	8.1	2.1	5.6
Pacific States	.1	.3	2.6	8.1	3.1	9.6
U.S. total	2.8	8.6	12.6	53.2	12.5	50.3

Figure 7 -- Estimated effect on farm income and direct government expenditures of planting flexibility scenarios



favor those crops with lower diversion requirements. Standardizing the rates with a generic requirement (F100G-P) is estimated to dampen crop mix response while harvested acreage declines slightly more, due largely to a net increase in the relative land diversion for wheat (the initial rate was 5 percent). Fewer acres in production further reduce chemical use although the environmental effects are offset by fewer crop shifts.

External Conditions

The analysis was conducted under certain assumptions regarding cropping alternatives, consistency of commodity program provisions, and initial demand and supply conditions. While the results portray increased planting flexibility as favorable to the environment, farm income, and the budget, changing these conditions could change the direction and strength of the results. For example, the inclusion of additional crops could amplify crop mix effects. In turn, if the production practices associated with these crops are less reliant on chemical inputs or are less erosive, this could enhance the environmental benefits.

A second consideration relates to the consistency of the economic climate throughout the analysis period. As noted earlier, demand, target prices, land diversion rates and loan rates, and production costs are assumed to remain constant. However, a shift in these parameters could lead to different results. For example, other analyses of planting flexibility suggest that harvested acreage for all crops is likely to increase reflecting projected growth in export and domestic demand (Agricultural Policy Working Group, 1989). Moreover, declines in stock levels resulting from two consecutive droughts may lead to lower land diversion requirements and increase the acreage available for production. While increased crop selection flexibility would allow program participants additional latitude to respond to changing market conditions, the environmental implications under these conditions are not clear. For example, demand growth that encourages crop mix shifts and production practice modifications that lead to more intensive tillage and chemical applications could adversely affect the environment. This implies that while planting flexibility may prove beneficial to the environment under the assumed economic conditions, should these conditions change, the results are not guaranteed.

Finally, the analysis does not capture potential production practice modifications, specifically the effect of planting flexibility on rotational practices. Because the use of fixed technologies also assumes fixed chemical use coefficients, the effect of planting flexibility underestimates potential chemical use response. For example, planting more soybeans following corn rather than monoculture corn lowers certain pesticide requirements (for example, corn rootworm pesticides). But the chemical data included in this report are taken from available production data and assume that average use rates remain constant. The model results thus underestimate the effects of chemical use.

Conceptually, planting flexibility would eliminate current program impediments that prevent or make unprofitable the adoption of rotations. However, rotational practices are influenced by a number of factors unrelated to current provisions. Ultimately, relative crop profitability, retooling costs, the availability of economic alternatives, and other factors affect rotation patterns.

Program Base Limitation - Sustainable Agriculture

The discussion surrounding sustainable agriculture has ranged from preserving family farming to food safety issues. Salient features of sustainable agricultural systems include long-term crop rotations, integrated crop-livestock operations, and substitution of labor, management, and capital for inorganic fertilizer, and chemical pesticide use (National Research Council, 1989). A central focus of all systems is to reduce agrichemical use in crop production (Fleming, 1987). However, there are strong economic forces at work which influence agrichemical use patterns in conventional agricultural practices (Daberkow and Reichelderfer, 1988).

Two approaches can be pursued to decrease fertilizer and pesticide applications. The first and direct method is to employ education, technical assistance, subsidy, tax, or regulatory techniques. Integrated pest management programs are an example. A second, indirect approach is to alter the economic incentives for crop composition choices so that less fertilizer and pesticides are used. Limiting permissible program base resulting in lower agrichemical use falls in the indirect category.

Option Definition

Detailed and comprehensive national information about the potential effects on agrichemical use by sustainable production systems is not available (National Research Council, 1989). For example, rotations of mixed grain and hay/legume crops can reduce required pesticide and nitrogen applications. However, as explained in the planting flexibility section, available national data do not fully capture input use changes from rotations. To the degree that sustainable agriculture practices with reduced agrichemical applications are adopted, the estimated adjustments in those variables using available agricultural production data can be viewed as lower bounds.

Given the lack of a comprehensive sustainable agriculture production data base, the analysis conducted for this report centered on indirect approaches to reducing agrichemical use. The first is increased planting flexibility already discussed. The second, base limitation, restricts the maximum amount of program acres any one producer may plant to a percentage of the producer's tillable cropland. This approach responds to the concern that commodity programs may cause unnecessarily high concentrations of monoculture and reliance on commercial chemicals (Duffy and Chase, 1989).

Analysis Procedures

To estimate how influential the commodity programs are in constraining rotation choices, a ratio of program base acreage divided by the farmer's total tillable cropland is calculated for each program participant. The ratio provides a measure of the degree of program enrollment on a farm and the potential impediment the commodity program imposes on diverse rotations. For example, a ratio of 1 indicates enrollment of all cropland in the commodity program. Given program participation, the farmer with all tillable acres enrolled generally cannot plant anything but the program commodity.3/ Only the set-aside acres in this instance could be used as part of a rotation

---

3/ As explained earlier, the 0-92 and possibilities of substituting soybeans, oats, or sunflowers on a portion of program base are exceptions.

although they cannot be harvested except in emergency situations.

An implicit assumption behind analysis using the ratio is that all cropland is equally capable of producing any crop. On farms and in areas where the assumption does not hold, the ratio will underestimate the potential constraint of commodity programs on the rotation decision. For example, if some acres used for soybeans are unsuitable for corn, the potentially flexible total falls and the ratio rises. Also, the analysis assumes feasible crop alternatives. Several geographic regions may be conducive for growing one crop only, such as northern wheat-producing regions in North Dakota. In these cases, a high ratio may suggest a rotation constraint when, in fact, a diverse rotation is not an option, thereby overestimating potential commodity program influence.

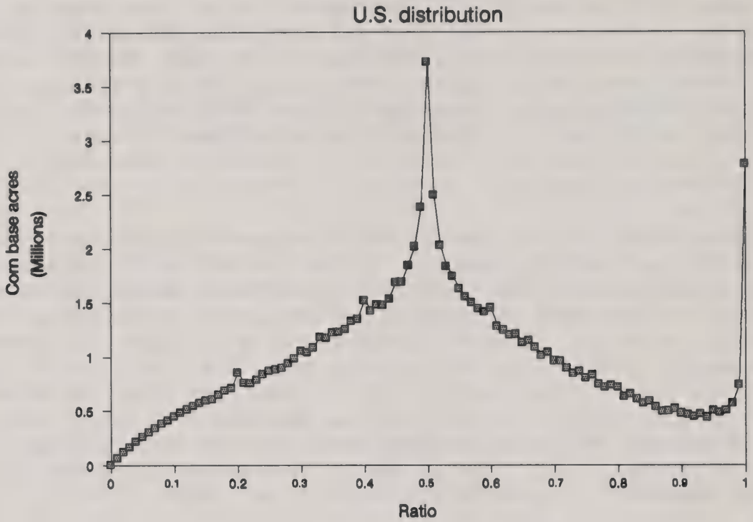
The ratio indicates what types of average rotations are feasible on a farm given program participation. For example, if the ratio is 0.50, an average 2-year rotation could be practiced, such as corn-soybeans on the entire farm. However, the ratio of corn base to cropland should not be construed to represent an actual rotation. The ratios are meant to estimate the potential influence of commodity programs on the decision to rotate. A ratio of 0.50 does not preclude a farmer from planting a continuous corn rotation on the corn base (such as monoculture) and following a rotation with other crops on the remaining 50 percent of the land. Many other factors influence the rotation decision (Heady, 1948). Again, the ratio measures the potential influence of the commodity program as a constraint to rotate.

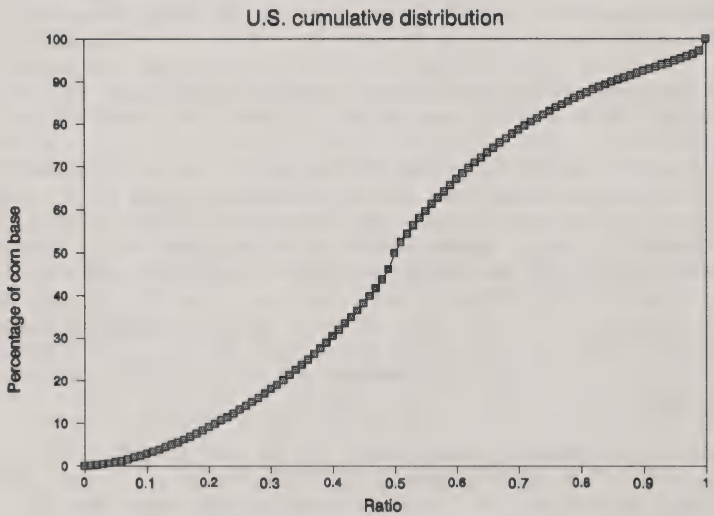
The focus is on farms with high base to cropland ratios that produce wheat and corn. Other program crops are not found at significantly high base-to-cropland ratios. Cotton, while one of the most intensively single-cropped commodities (Daberkow and Gill, 1989) did not appear on many acres with high base-to-cropland ratios (see Frerichs for a full discussion of the ratio and its limitations). Figures 8 and 9 show the national acreage and percentage distributions of corn and wheat base ratios. The distributions of both are very similar. Salient features include spikes at the 0.50 and 1 ratio level.

The motivating force behind the base limitation option is to increase crop mix and rotational diversity on farms that are highly specialized in a single commodity. The base limitation approach would require farmers with base above a given ratio to plant the acres above the ratio to another crop. Table 5 lists by production region the amount of corn and wheat base acres in 1988 that would be required to be planted to other crops under 33, 50, and 66 base-to-cropland ratio limitations. Not surprisingly, those production regions with comparative advantages in corn (Corn Belt, Lake States, and Northern Plains) or wheat (Northern Plains and Southern Plains) are heavily influenced by these restrictions.

The national/regional programming model employed in the planting flexibility analysis is also used to estimate changes under the three scenarios (Konyar, McCormick, and Carey, forthcoming). A limitation of the model for the base limitation analysis is the shortage of alternative crops. Comprehensive production, yield, and cost data, unfortunately, are not available for most crops not supported by commodity programs. These alternative crops, such as sunflowers, flax, and rapeseed can be important crop alternatives in several regions. Their absence limits the extent of the analysis. How much the limitation affects the extent of cropping changes is unknown.

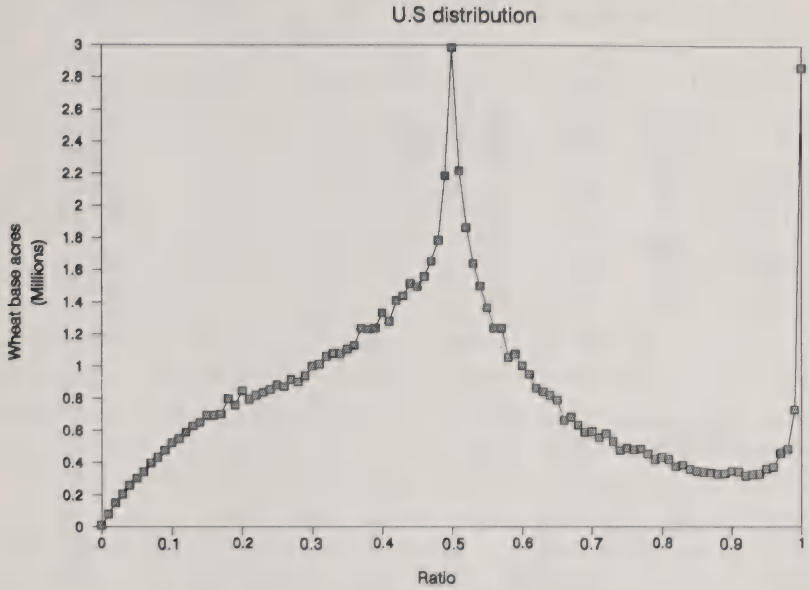
Figure 8 -- Corn base acreage by corn base cropland ratio 1/

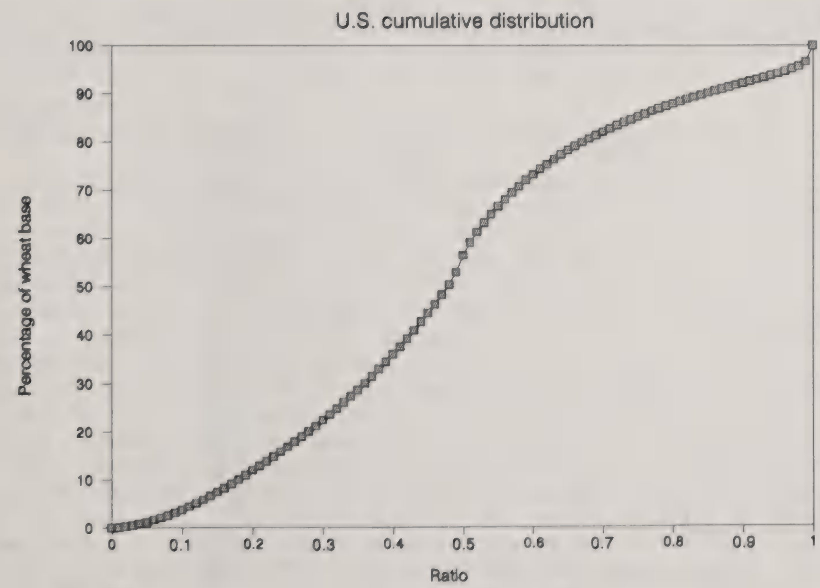




1/Ratio is computed as program corn base divided by tillable cropland for each farm with a record of corn base with U.S. Department of Agriculture's Agricultural Stabilization and Conservation Service.

Figure 9 -- Wheat base acreage by wheat base to cropland ratio 1/





1/ Ratio is computed as program wheat base divided by tillable cropland for each farm with a record of wheat base at the Agricultural Stabilization and Conservation Service.

Table 5--Reduction in regional corn and wheat base under a 33-, 50-, or 66-percent base limitation scenario

Region	Corn			Wheat		
	33%	50%	66%	33%	50%	66%
			1,000 acres			
Northeast	558	257	100	93	3	1
Appalachian	724	273	92	138	45	14
Southeast	248	86	29	216	87	31
Lake States	2,899	1,214	431	592	239	78
Corn Belt	10,237	4,750	1,945	267	91	32
Delta States	93	33	12	292	122	45
Northern Plains	5,024	2,625	1,220	6,862	2,848	1,092
Southern Plains	1,429	741	351	5,068	3,175	1,755
Mountain States	368	191	85	2,083	606	174
Pacific States	60	25	9	783	232	71
Total	21,640	10,195	4,274	16,394	7,448	3,293

Source: U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, 1988

A second key limitation of the model is its inability to measure the substitution of inputs as cropping diversity increases. The model captures only changes in inputs from crop and acreage shifts, such as changes from corn to soybeans. Input use is fixed in the model by crop and production region according to existing survey information. This is critically important for the base limitation cases which are trying to induce rotations and the substitution away from commercial chemicals. For example, the model does not capture the reduction in nitrogen and corn rootworm pesticides when moving to a corn-soybean-oats rotation from continuous corn.

Results

Figures 10 and 11 show the estimated changes in national acreage, price, farm income, and government deficiency payments under the 33-, 50-, and 66-percent base limitation scenarios. The larger shifts are generally confined to corn and wheat as these two crops are directly affected by the base limitations. Much of the corn and wheat acreage restricted by the limitation falls out of production, or drops out of the commodity program and shifts to farmers not participating in the corn or wheat program because of rising prices. For example, as the base limit is tightened from 66 to 33 percent, the amount of corn production by nonparticipants grows from 11 to 33 percent of all corn acres harvested, while the total number of harvested acres of corn falls by 15 percent. The decrease in acreage occurs as many corn acres are not profitable without the support of commodity programs. Moreover, an arbitrary limit in each region works against regional comparative advantages of certain crops. As the limit is tightened, the production of nonparticipating corn and wheat becomes more profitable due to the decrease in overall corn and wheat acreage and actually pulls soybean acreage out of production and into corn. For example, there is a 1-percent fall in soybeans under the 33-percent limit.

The production of other commodities is not affected under the 66-percent limit and only in a minor way under the tighter limitation scenarios. Total net

Figure 10 -- National crop acreage changes under 33-, 50-, and 66-percent base limitation scenarios

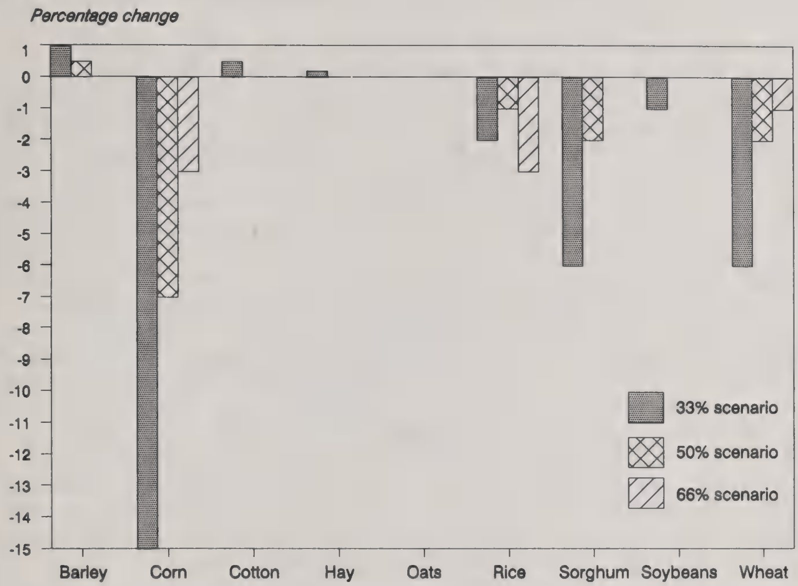
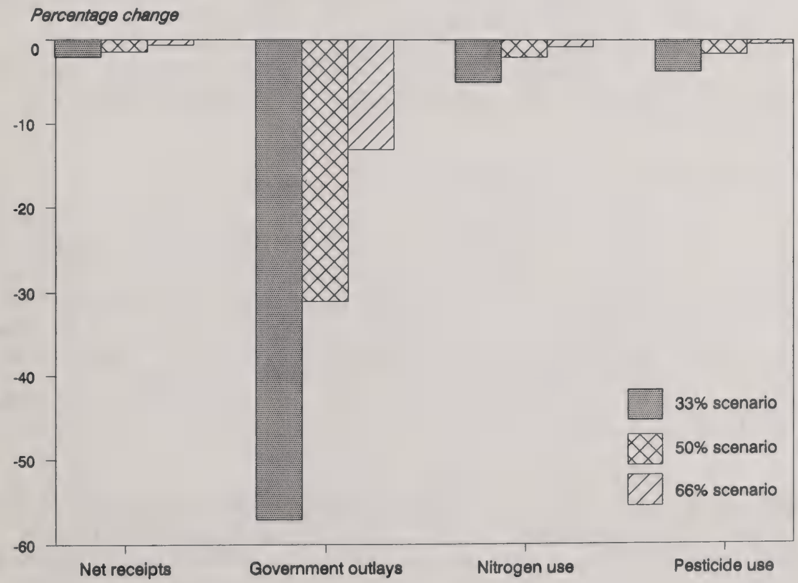


Figure 11 -- National percentage changes in net receipts, government outlays, nitrogen and pesticides use under 33-, 50-, and 66-percent base limitation scenarios



receipts (gross receipts minus variable costs) fall under each scenario with the largest being a 2-percent drop under the 33-percent option. Assuming no payments on the restricted acres, government outlays in the form of deficiency payments fall 13, 31, and 57 percent, respectively, for increasingly stringent levels. If deficiency payments were continued on the restricted acres, the drop in government outlays would be less but still occur due to rising program crop prices.

National quantities of inputs decrease under each scenario. Nitrogen expenditures fall about 5, 2, and 1 percent under the 33-, 50-, and 66-percent scenarios, respectively, whereas herbicides, insecticides, and fungicides as a group fall approximately 4, 2, and 0.5 percent for the same scenarios.

However, national nitrogen and pesticide leaching potential is projected to increase on vulnerable soils for the 50- and 66-percent limitation scenarios (fig. 12). The predominant decreases in agrichemicals occur in the Corn Belt and Northern Plains where vulnerability from input use is lower than the rest of the Nation. Increases in corn acreage and, to a lesser degree, wheat acreage in the Mountain States and Southeast, however, more than offset improved ground-water leaching vulnerability by the other decreases in the 66- and 50-percent scenarios. Both the Mountain States and the Southeast have a larger share of soils vulnerable to leachable chemicals than the Corn Belt and Northern Plains. In effect, the acreage changes, associated input use changes, and resource conditions in these production regions offset the changes in the Corn Belt and Northern Plains. Under the 33-percent scenario, the Corn Belt, Northern Plains, and Southern Plains are large enough to result in a national reduction in high vulnerability conditions to leachable nitrogen of about 6 percent but virtually the same level for pesticides.

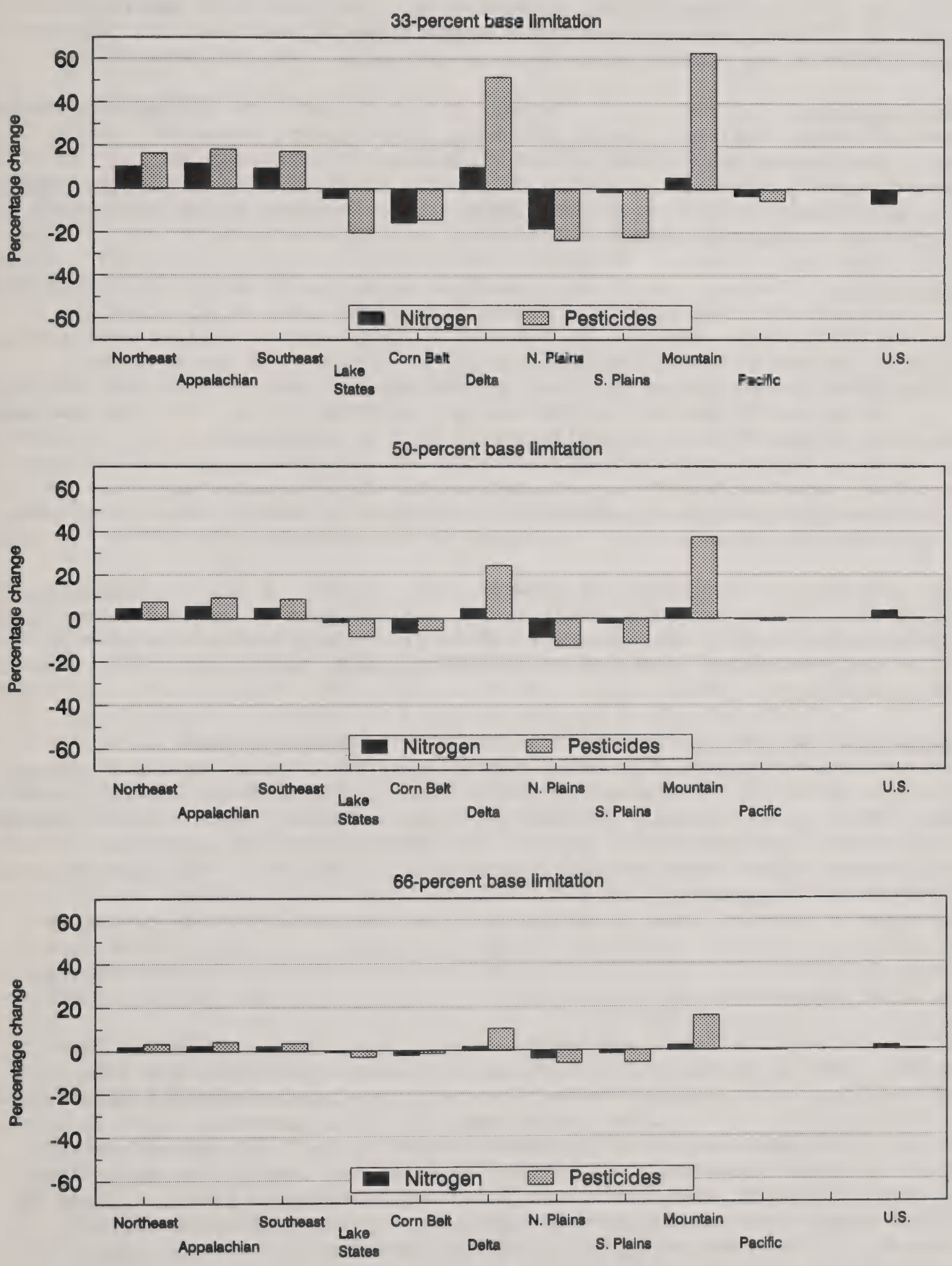
It should be noted that the increases in Mountain State acres planted to corn are likely overstated due to incomplete information in the model. These increases are driving the large percentage changes in leaching potential in the Mountain States. To the extent that the acreage shifts are overestimated, the leaching potential is inflated. Also, recall that the chemical input adjustments do not capture any changes from rotational changes. Thus, the entire analysis may be underestimating total chemical reductions and improved leaching conditions to the extent that more diverse rotations are adopted under the base limitation option.

Agricultural Wetland Protection

The President's "no net loss of wetlands" policy, included in the 1990 budget message to Congress, has given increased visibility to wetland conservation efforts (Conservation Foundation, 1988). That policy statement emerged from the recommendations of the National Wetlands Policy Forum, and those of the National Wetland Priority Conservation Plan required by the Emergency Wetland Resources Act (1986) and the North American Waterfowl Management Plan. The 1985 Food Security Act created the Swampbuster provision to remove agricultural program incentives for converting existing wetlands into drained cropland. New wetland protection initiatives were included as part of the 1990 farm bill.

One option is to create an agricultural wetland reserve (Heimlich, Carey, and Brazee, 1989). The reserve's purpose is to retire cropped former wetlands from production and restore them to secure environmental benefits of increased wetland acreage. An indirect potential benefit of the reserve is to reduce

Figure 12 – Estimated regional effects of base limitation scenarios on pesticide and nitrogen leaching potential



the current and future production of crops in excess supply, thereby lowering associated government and social costs.

Wetland Design

The structure and operation of the reserve will determine the nature and magnitude of the government and other economic costs incurred. Policymakers face options along several dimensions in designing a wetland reserve.

Land Interest. To effectively protect or restore wetlands, the government has three principal options: lease, purchase, or permanent easement. Annual or short-term leases may not offer sufficient security of tenure if capital investment subsidies are necessary to restore the wetland. Of the two long-term approaches, easements should involve lower acquisition and management costs than outright purchase.

Composition. Wetlands previously converted to agricultural use are candidates for restoration in the reserve. Almost 56 million acres of cropland on drained hydric soils reported in the 1982 National Resources Inventory (NRI), about 13 percent of total cropland, could be eligible for restoration. Existing wetlands could be included in the reserve, but they are currently eligible for enrollment in the CRP, as well as USDA's Water Bank Program, and Interior's Small Wetland Acquisition Program. Estimating costs of easements on existing wetlands is difficult and there is a potential problem of enrolling land that would not be converted to cropland under any circumstances. For these reasons, this analysis is restricted to restorable cropped former wetlands.

Size. At rates of wetland loss between 1954 and 1974, 2.5-, 5-, and 10-million-acre reserves would offset 6, 13, and 25 years of wetland conversion due to agriculture. A key question is the effect of reserve size on crop prices and production incentives on remaining land, termed indirect production intensification.

Operation. Reserve operation procedures might resemble the CRP implementation, but would probably differ from CRP in some important respects. Eligible former wetlands could be defined and possibly ranked in environmental importance. Then a bidding process could be conducted. Based on the bids and a detailed evaluation of the economic and environmental value of the offered land, negotiations could proceed to arrive at a final value for the rental or purchase and management terms for the land. Bids should reflect the landowner's expected loss in net income from crop and livestock production, including any retired crop base acreage, plus other adjustment costs incurred. Costs of restoring the land to wetland condition (such as plugging drains) could be paid in full or shared between the government and the landowner.

Market values of wetlands and hydric cropland are usually different from the social value of the functions performed by restored wetlands. For example, wetlands perform a socially valued flood control function which generally has no market value. A least-cost enrollment strategy, therefore, may or may not obtain the highest social wetland benefits per dollar. A cost-effective strategy should enumerate public benefits from each restorable wetland parcel offered and compare them with acquisition and restoration costs. It may be that a least-cost reserve captures many of the wetland benefits society demands, or that most socially valuable wetlands are also valued highly in agricultural production terms.

Identifying priority wetlands is important in order to focus wetland restoration efforts on those wetlands most in need or provide the most benefit for a given expenditure. The Emergency Wetland Resources Act of 1986 provides general criteria for identifying priority wetlands. These criteria include past and current rates of wetland loss and measures of the ecological and economic values of the wetlands. These values include endangered and threatened species, migratory birds, habitat, commercial and sport fisheries, water quality and quantity, flood control, and recreation.

Options Analyzed

Selected sizes of a reserve of cropped former wetlands are evaluated as options: 2.5, 5, and 10 million acres. The wetlands would be protected through acquiring permanent easements with compensation for commodity base reductions and full reimbursement of restoration costs. Enrollment would proceed over 1991-95 to acquire the least expensive (easement plus restoration costs) eligible former wetlands.

Analysis Procedures

Land retirements under the reserve options are subtracted from national and regional cropland bases to evaluate agricultural economic effects. The Agricultural Resources Model is used to assess the national and regional economic effects (app. 1). Environmental effects on surface-water quality, agrichemical leaching, and wildlife habitat are also evaluated and economic benefits from water quality improvements, reductions in flood damages, and increases in waterfowl hunting are estimated.

National Results

Table 6 and figure 13 display the distributions of crops produced on and State acreages of selected least-cost wetland reserves. The largest acreage would be enrolled in the North Central and Corn Belt States, with the greatest effect in Minnesota. Generally, corn and soybean production are most affected, with wheat about one-third less. Subsequent to enrollment, shifts in crop production induced by higher prices modify the crops and regions affected somewhat, cutting the reduction of corn acreage in half and decreasing reductions in soybean and wheat acreage slightly. Reductions in sorghum, oats, and nonprogram crops replace some of the corn, soybean, and wheat adjustments. The total reduction in cropland after changes induced by higher prices is only 72 percent of the original retirements of 2.5, 5, and 10 million acres.

Crop prices are projected to rise above base levels in accord with the simulated production decreases from less than 1 percent for soybeans and cotton up to 2.5 percent for oats under the 2.5-million-acre option, and from 2.5 percent for soybeans and cotton up to 9 percent for oats if as many as 10 million acres are enrolled (table 7). Net farm income thus increases from about 0.5 to 1 percent for the reserve sizes considered.

In response to wetland enrollment, three types of government costs are affected: easement acquisition costs, restoration expenses, and commodity program costs, including reduced deficiency payments and storage expenses (table 8). Easement expenses are projected as foregone net returns to the farmer on the converted cropped wetlands, including lost commodity program benefits (Heimlich, 1989). While net returns on restorable former wetlands

Table 6--Estimated crop acreage composition of selected least-cost wetland reserves

	Enrolled in reserve 1/ (reserve size in million acres)			Net change after adjustment 2/ (reserve size in million acres)		
Crop	2.5	5	10	2.5	5	10
			Percent			
Soybeans	31	28	31	23	26	24
Corn	32	30	32	16	14	16
Wheat	22	24	20	20	18	17
Cotton	1	1	1	1	1	1
Oats	6	5	4	10	8	8
Sorghum	1	1	1	9	9	11
Barley	5	4	3	4	4	4
Program crops	96	94	93	83	80	81
Nonprogram crops	4	6	7	17	20	19
Total reduction	100	100	100	72	72	72

1/ Based on 1982 National Resources Inventory data.
2/ Based on the Agricultural Resources Model estimates after changes in crop acreage induced by price changes from enrolling cropped former wetlands.

Figure 13 -- Least-cost, 5-million-acre wetland reserve

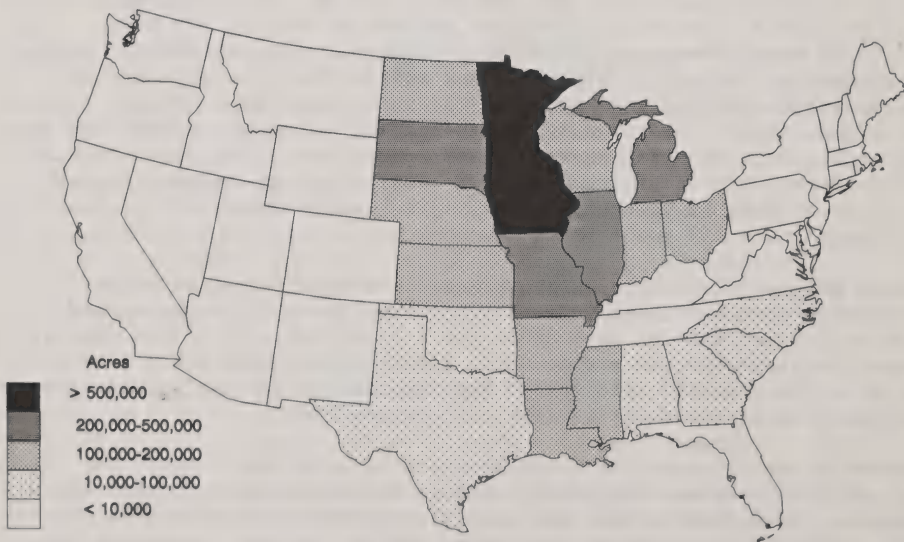


Table 7--Estimated changes in crop production and prices on selected least-cost wetland reserves

Crop	Crop production (reserve size in million acres)			Crop prices (reserve size in million acres)		
	2.5	5	10	2.5	5	10
				Percent change 1/		
Soybeans	-0.7	-1.5	-3.0	0.6	1.2	2.4
Corn	-.5	-.9	-2.0	1.3	2.4	5.2
Wheat	-.6	-1.1	-2.3	2.0	3.5	7.1
Cotton	-.1	-.3	-.6	.6	1.3	2.4
Oats	-2.4	-4.2	-8.6	2.5	4.2	8.7
Sorghum	-1.7	-3.6	-8.1	1.4	2.9	6.6
Barley	-.9	-1.5	-2.9	2.1	3.4	6.6

Source: Agricultural Resources Model estimates.
1/ From baseline conditions.

Table 8--Estimated government cost summary of selected least-cost wetland reserve sizes

Item	Reserve size (million acres)		
	2.5	5	10
		Billion dollars 1/	
Easement costs	0.6	1.7	5.2
Restoration costs	.3	.7	1.5
Total costs	.9	2.4	6.7
Commodity program savings	1.6	2.9	6.0

1/ Sum of undiscounted costs from 1991 through 1996.

are estimated using target prices, the analysis does not fully reflect the opportunity cost of base acreage loss. Easement costs may be higher than estimated where the productivity of cropland required to be set aside in place of restored wetlands is higher than that of the cropped former wetlands previously used to meet ARPs. Restoration expenses are approximated from data on specific State and Federal restoration projects (Heimlich, 1989; Heimlich, Carey, and Brazee, 1989).

Savings in government commodity deficiency and storage payments from reduced production and higher prices are substantial under present conditions since 1989-90 commodity carryover stocks are at low levels. Reduced production from the wetland reserve is estimated to have price effects which generate deficiency payment savings. These cost savings also depend on the assumption

that projected ARP levels are unchanged through 1991-95. If the ARP percentages are relaxed as wetland acquisition proceeds, the savings would be diminished.

The potential environmental benefits of added wetlands are diverse, ranging from fish and wildlife habitat, hydrologic services such as flood retardation and groundwater recharge, and market and nonmarket values from commercial fishing and trapping, recreational fishing and hunting, and scientific and recreational nature study (Heimlich and Langner, 1986; Shabman and Batie, 1985). These benefits are extremely difficult to estimate given the site-specific and often nonmarket character of wetland values (Amacher and others, 1988).

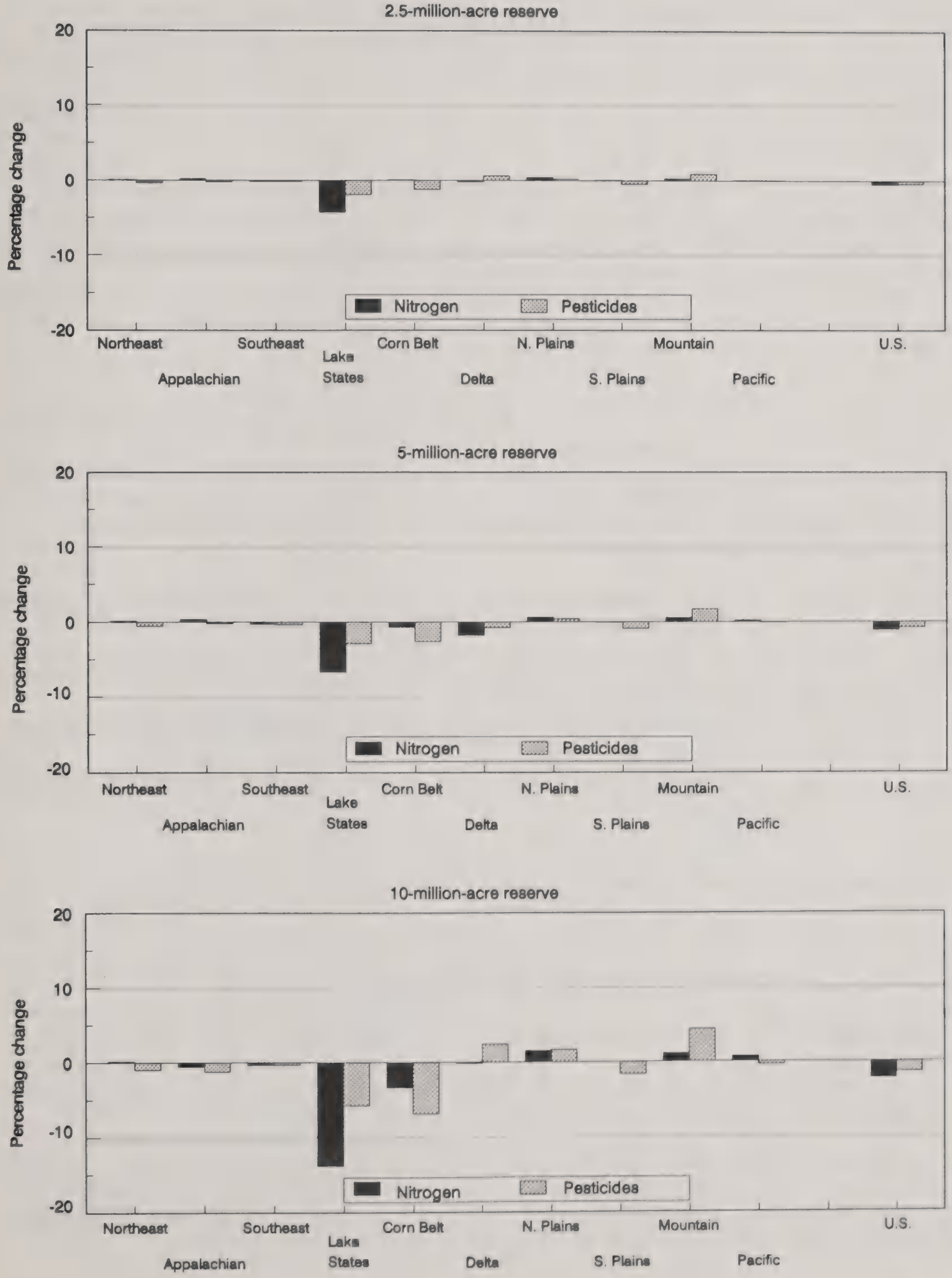
Three classes of benefits are approximated on an aggregate basis (table 9). Increased waterfowl hunting by 0.3 million to 1.3 million new hunters due to increased habitat and bird populations could add benefits of $1.2 billion to $4.4 billion over 1991-2000. Appendix 4 explains the general procedures used in making these estimates. Water quality improvements over the period 1991-2000 from reduced erosion on former cropland and from filtering or buffering sediment from adjacent croplands are estimated to range from a low of $55 million for 2.5 million acres to a high of $720 million for a 10-million-acre reserve (app. 2). Restoration of former wetlands also reduces agrichemical loadings on those acres. Overall, reductions in leachable pesticides and nitrates in vulnerable situations (app. 3) are estimated to range from 0.5 to 2.2 percent for wetland reserves ranging from 2.5 million to 10 million acres (fig. 14). Finally, reductions in flood damages from increased floodwater retention range from $0.7 billion to $2.8 billion during 1991-2000. Note that these benefits, which are new economic gains to society, are not equivalent in nature to government cost savings, which are primarily avoided transfer payments.

Table 9--Estimated benefits of selected least-cost wetland reserve sizes

Item	Reserve size (million acres) 2.5	5	10
		Billion dollars 1/	
Waterfowl hunting	1.2	2.2	4.4
Water quality:			
Low	.1	.1	.2
High	.2	.4	.7
Flood control:			
Low	.7	1.4	2.7
High	.7	1.5	2.8
Total:			
Low	2.0	3.7	7.3
High	2.1	4.1	7.9

1/ Sum of benefits from 1991 through 2000.

Figure 14 -- Estimated regional effects of a wetland reserve on pesticide and nitrogen leaching potential



Some qualifications to the benefit estimates should be made. Estimated surface-water quality improvement benefits are based on erosion reductions from wetland restoration and do not reflect sediment filtering and nutrient uptake from the restored wetland vegetation. Waterfowl hunting benefits are estimated only for new hunter participation resulting from increased wetland habitat and presumed increases in waterfowl populations, and do not reflect increased participation by existing hunters. Flood damage reductions may be overstated because they do not reflect construction of flood control structures in response to increased damages resulting from previous wetland losses.

Regional Results

A wetland reserve program will affect some regions with larger amounts of cropped former wetlands more than others (table 10). While the Lake States, particularly Minnesota, contribute the most acreage to each wetland reserve, the largest increase in wetlands relative to remaining wetlands occurs in the Corn Belt, followed by the Lake States and the Northern Plains. The relative change in wetlands is small for areas such as the Southeast and Delta States which have large amounts of remaining wetlands.

Net change in cropland harvested, after offsetting increases due to higher prices, is reduced most in the Lake States, Corn Belt, and Delta, while the Northern Plains and Mountain regions have small increases. Changes in farm income are not proportional to changes in harvested acreage and are positive in all cases except the Lake States. However, this accounting does not include payments for permanent easements, which should offset the loss of farm income from current production.

Benefits from increased wetland acreage are generally proportional to acreage enrolled, with the largest benefits occurring in the Lake States and Corn Belt. Decreases in flood damages due to increased flood retention in the wetlands disproportionately affect the Northern Plains and Corn Belt, where damages are low and historical wetland losses high. Changes in potential pesticide and nitrate leaching are proportional to wetland acreage restored, but may actually increase in regions where offsetting acreage enters production due to higher prices, such as the Delta States, Mountain, Pacific, and Northern Plains regions.

Conservation Reserve Program: Contract Extension and Expansion/Redirection

At least two important issues have surfaced during implementation of the CRP. First, there is concern that large amounts of CRP land will return to intensive crop production when the 10-year contracts expire. This could result in a loss or reduction of existing CRP environmental benefits and has led to interest in options for assuring continuation of those benefits. Second, due in part to refocused national environmental goals, proposals were made to redirect and expand the CRP under the 1990 farm bill. Redirection of the CRP would deemphasize general soil erosion control in favor of water quality improvement and the protection of wetlands. Suggested levels of expanded enrollment have ranged from 5 million to 25 million acres. In this report, analyses of specific program options included 10-year extensions of selected contracts to preserve existing CRP benefits, and 5- and 10-million acre CRP expansions directed to improve surface-water quality.

Table 10--Estimated regional effects of selected least-cost wetland reserve sizes

Region	Wetlands	Crop acreage	Farm income	Water quality	Hunt-ing	Flood damages	Pest-icides	Nitrates
			Percent change from base					
2.5 million acres:								
Northeast	0.1	0	1.4	0	0.4	0	(-0.3)	0.1
Appalachian	.2	0	1.2	0	.4	(-.2)	(-.2)	.2
Southeast	.1	(-.3)	1.0	.1	2.5	(1.4)	(-.1)	(-.1)
Lake States	9.4	(-4.7)	(-1.7)	1.1	76.5	(-48.0)	(1.9)	(4.3)
Corn Belt	27.1	(-.7)	.3	.4	26.5	(-5.2)	(1.2)	.1
Delta States	.8	(-.4)	.3	.1	2.5	(-1.1)	.6	(-.2)
N. Plains	3.0	.5	1.1	(-.1)	6.9	(-8.7)	.2	.4
S. Plains	0	.1	0	0	0	0	(-.5)	.1
Mountain	0	.1	1.2	0	0	0	.9	.3
Pacific	0	(-.2)	1.0	0	.2	0	.1	.1
United States	3.0	(-.6)	.4	.1	13.5	(-4.2)	(-.4)	(-.5)
5 million acres:								
Northeast	.2	(-.1)	2.5	0	1.0	(-.1)	(-.6)	.1
Appalachian	.3	0	2.3	0	.7	(-.2)	(-.2)	.3
Southeast	.3	(-.6)	1.7	.3	6.6	(-3.7)	(-.4)	(-.3)
Lake States	15.5	(-7.0)	(-2.3)	1.7	127.1	(-48.0)	(2.9)	(6.7)
Corn Belt	64.9	(-1.5)	.4	.8	63.6	(-12.4)	(2.6)	(-.7)
Delta States	1.7	(-3.5)	.3	1.1	4.9	(-8.7)	(-.8)	(1.8)
N. Plains	9.4	.8	2.0	(-.2)	21.8	(-27.5)	.4	.6
S. Plains	1.7	(-.1)	0	0	1.6	(-2.2)	(-.9)	(-.1)
Mountain	.1	.2	2.1	0	.3	(-.9)	1.7	.5
Pacific	.4	(-.3)	1.6	0	1.2	(-.2)	(-.1)	.2
United States	6.4	(-.6)	.6	.3	25.7	(-9.2)	(-.8)	(1.1)
10 million acres:								
Northeast	.5	(-.3)	5.2	0	2.3	(-.2)	(-.9)	.2
Appalachian	5.5	(-1.6)	3.6	.2	12.0	(-4.4)	(1.2)	(-.5)
Southeast	.5	(-1.1)	3.8	.5	10.3	(-5.7)	(-.3)	(-.4)
Lake States	27.8	(-14.0)	(-40.9)	3.3	227.6	(-48.0)	(5.7)	(13.8)
Corn Belt	158.2	(-4.2)	.2	2.3	154.9	(-30.2)	(6.8)	(3.3)
Delta States	3.9	(-2.1)	2.5	.6	11.6	(-5.1)	2.4	(-.1)
N. Plains	15.0	2.0	4.2	(-.4)	35.0	(-44.0)	1.7	1.5
S. Plains	2.3	0	0	0	2.2	(-2.9)	(1.6)	0
Mountain	.6	.3	4.4	0	.8	(-3.7)	4.4	1.1
Pacific	.7	(-.2)	3.1	0	.9	(-.3)	(-.4)	.7
United States	12.8	(-2.6)	1.2	.6	50.7	(-16.9)	(1.4)	(2.2)

Design Questions - CRP Contract Extensions

Under the CRP, contracts are established to retire highly erodible cropland from production for 10 years. During the contract, CRP acres are placed in grass, trees, or other conservation uses. The CRP land use change provides numerous environmental benefits including improvement of surface-water quality, creation of wildlife habitat, preservation of soil productivity, protection of ground-water quality, and reduction of wind erosion damages. At the end of the contract period, annual rental payments made by USDA to CRF farmers cease, providing a strong incentive for most CRP land to return to crop production if prices are favorable. Recultivating CRP land could result in a loss or reduction of environmental benefits provided by the program.

Following the CRP's predecessor, the Soil Bank Program of 1956-62, a large percentage of enrolled acreage not planted to trees was returned to agricultural production due to favorable crop prices. While it is impossible to know the level of prices that will exist when current CRP contracts expire, recent improvements in the agricultural economy, stronger current prices, and rising expectations all suggest that a large percentage of CRP acres may return to crop production. In addition, if commodity program base acreage were retired as a condition of CRP enrollment, a farmer will progressively lose that base unless it is replanted soon after the CRP contract expires. Roughly two-thirds of the land enrolled in the CRP has base acreage that could be reduced.

Effective implementation of the 1985 Food Security Act conservation compliance provision would do much to limit resurgence of excessive soil erosion and attendant water quality problems from about 80 percent of CRP land if returned to production. However, recultivation of CRP land could bring about a loss of other environmental benefits that were provided during the contract period. Among these are protection of wetlands and provision of wildlife habitat.

One option for preserving CRP benefits would be to continue base acreage protection after the contract period if the producer retains CRP land in a protective cover. While this removes the farmer's motivation to recultivate solely to avoid loss of base, continued base protection may not be sufficient to ensure that CRP land will not be returned to production. Unless the land is incapable of producing at a profit, most farmers would rather put the land back into production and earn deficiency payments and other returns than let it remain idle with base protection but with no economic return. Allowing farmers some limited commercial use of CRP cover (such as hay or grazing), in addition to continued base protection, would provide a greater incentive for some farmers to forego immediate recultivation.

A more effective but also more costly option for long-term retention of CRP environmental benefits might be to negotiate extensions of contracts on land with precisely targeted environmental values. Ideally, the benefits generated by continued retirement of each CRP acre could be compared with the cost of contract extension to identify CRP land with the greatest net benefit. However, a more practical approach would be to offer contract extensions on CRP land that is judged to provide large net benefits based on type of CRP cover or other physical criteria. Examples of such land could include CRP acres specifically devoted to wildlife habitat, filter strips along waterways, field windbreaks, cropped wetlands, CRP land not subject to conservation compliance, and CRP land that would likely opt out of conservation compliance due to high compliance costs (such as land with the highest rates of erosion

when cropped). Farmers with CRP land targeted for environmental benefits could be approached with one of several contract extension options, which include:

- o Continuation of annual rental payments for a new contract period (such as 10 years),
- o Continuation of reduced annual rental payments for a new contract period with limited commercial use of forage subject to environmental safeguards (Heimlich and Kula; Heimlich, Wrona, and others, 1989),
- o Purchase of conservation easements restricting environmentally damaging uses.

Emphasis could be placed on CRP lands most likely to return to production that would cause the greatest environmental damages. For example, CRP land subject to effective conservation compliance restrictions might not be a priority for contract extension, nor would land planted to CRP trees since experience shows that this land is less likely to return to production.

Design Criteria - Redirection/Expansion of CRP for Surface-Water Quality

A refocusing of national environmental goals since the 1985 farm bill has altered the context for considering CRP options for the 1990's. Reductions in soil erosion and preservation of soil productivity, both important in the 1985 farm bill, are now perceived to be less important relative to other goals including the improvement of water quality and the protection of wetlands. After the ninth signup held in July-August 1989, CRP enrollment stood at 33.9 million acres. Most of this acreage was located in the Western United States where the main environmental benefit is wind erosion reduction. If CRP acreage were expanded, current national goals would suggest that additional land be targeted to improvement of water quality and/or protection of wetlands or other environmentally fragile areas.

Expansion of the CRP to achieve surface-water quality goals would require changes in existing program operating rules. The period for enrolling new land would probably be extended beyond the 1990 crop year, possibly to 1995. Eligibility criteria for field enrollment would also be modified to target water quality improvement. Possible guidelines for establishing eligibility could include:

- o Eligibility could be broad with respect to land classes and erosion rates. Even highly productive cropland with low erosion rates can significantly impair surface-water quality if located near a river or lake,
- o Eligibility could be limited to cropland that impairs existing or potential uses of surface water, and
- o Eligibility and enrollment procedures could be coordinated with State water quality officials responsible for surface-water pollution control. This would capitalize on expertise to identify and control nonpoint source pollution problems addressed under section 319b of the 1987 Clean Water Act.

Under such guidelines, CRP enrollment patterns would likely shift from western areas with high rates of wind erosion to areas with identified surface-water quality problems such as the Northeast, Lake States, and Corn Belt regions. Different crop acreages would also be affected due to this shift. While a high proportion of existing CRP enrollment has retired wheat acreage, a large amount of land targeted by a water quality expansion/redirection of the CRP

would be acres now in corn production.

Results - CRP Contract Extensions

Just under 7 million acres of the 30.6 million acres enrolled in CRP signups 1-8 were identified as potential candidates for contract extension based upon conservation cover or physical characteristics. These acres were judged likely to provide nonmarket environmental benefits not protected by conservation compliance or other mechanisms, and to have a high probability of being recultivated following contract expiration. Based on the experience of earlier programs, CRP acres planted in trees were assumed to have a large probability of remaining out of production following contract expiration and thus were not considered for contract extension. The relatively small amount of CRP acreage devoted to permanent wildlife habitat, field windbreaks, shallow water areas for wildlife, wildlife food plots, filter strips, and wetlands were presumed to have large environmental benefits relative to other CRP land and were selected for contract extension. CRP grass acres with retired commodity bases were selected for contract extension only if pre-CRP erosion rates exceeded 7.5 times the tolerance level. It was assumed that these acres would have a high probability of returning to crop production and that they would revert to high erosion rates even under conservation compliance plans. Finally, CRP grass acres on farms without commodity bases were selected for contract extensions since the farmers who cultivate this land receive no commodity program payments and thus would be less likely to implement a conservation compliance plan after contract expiration.

Falling into six different categories, the nearly 7-million-acre total represents 1.5 million acres of dedicated wildlife habitat, 40,000 acres of filter strips, 6,000 acres of field windbreaks, 17,000 acres of formerly cropped wetlands, 4.5 million acres of land with extreme erosion rates when cropped, and 418,000 acres of land not subject to conservation compliance due to commodity program nonparticipation (Osborn and others, 1989).3/ Acres were selected on an individual basis. In other words, if a particular contract contained 25 acres of permanent wildlife habitat and 200 acres of upland grass that would be subject to conservation compliance, only the wildlife habitat acres were targeted for contract extension. Remaining farm CRP acres on which contracts would not be extended were projected to retain most environmental benefits because of conservation compliance restrictions or because they are planted in trees and should remain out of crop production for an extended period.

The total government rental cost for 10-year contract extensions, if acquired in 1990, on the identified 7 million acres is estimated to be $3.3 billion, an annual payment averaging $48 per acre. This assumes that contracts for selected acres can be extended for their existing annual rental payment rate. Costs could be greater if commodity prices at the time of extension are significantly higher than when the contract was established or if rental payments are adjusted for the effects of interim inflation.

Possible production and price effects of contract extensions depend upon the

---

3/ Contract extensions might also be offered on land eligible for and enrolled in CRP but not considered highly erodible under conservation compliance. However, the extent of this land could not be estimated from available data.

continuing operation of other supply control and land diversion programs. Since contract extensions would not take place until 1996 and beyond, projections of government acreage diversion levels are highly uncertain. Consequently, production and price effects of selected CRP contract extensions were not estimated but are expected to be small.

Contract extensions were estimated to reduce annual soil erosion by an average of 245 million tons per year, compared with the erosion that would occur if these acres returned to crop production. This implies an average erosion reduction of 36 tons/acre/year for acres with extended contracts, which exceeds the average erosion reduction for all CRP land by 16 tons/acre/year. Surface-water quality benefits from selected contract extensions were estimated to total $353 million to $1,148 million, or $5 to $17 annually per acre. These benefits, which include maintaining 40,000 acres of existing CRP filter strips for an additional 10 years, are not significantly different from per acre water quality benefits on all CRP acres. Because contract extensions draw only from land currently enrolled in the CRP, per acre environmental benefits may be less than the benefits from new CRP enrollment specifically targeted, for example, to water quality.

Total wildlife benefits due to selected contract extensions were estimated at $83.7 million, or approximately $1.20 per acre annually. This includes benefits from 1.5 million acres of CRP land that provide specific wildlife benefits including food, cover, and shallow water areas. Contract extensions would also result in some continued protection of ground water from leaching fertilizers and pesticides. The regional effects are displayed in figure 15. Average reductions in nitrogen fertilizer and pesticides leaching in vulnerable areas (app. 3) amount to approximately 2 percent for contract extensions on the identified 7 million acres over the period 1996-2009.

Results - CRP for Surface-Water Quality

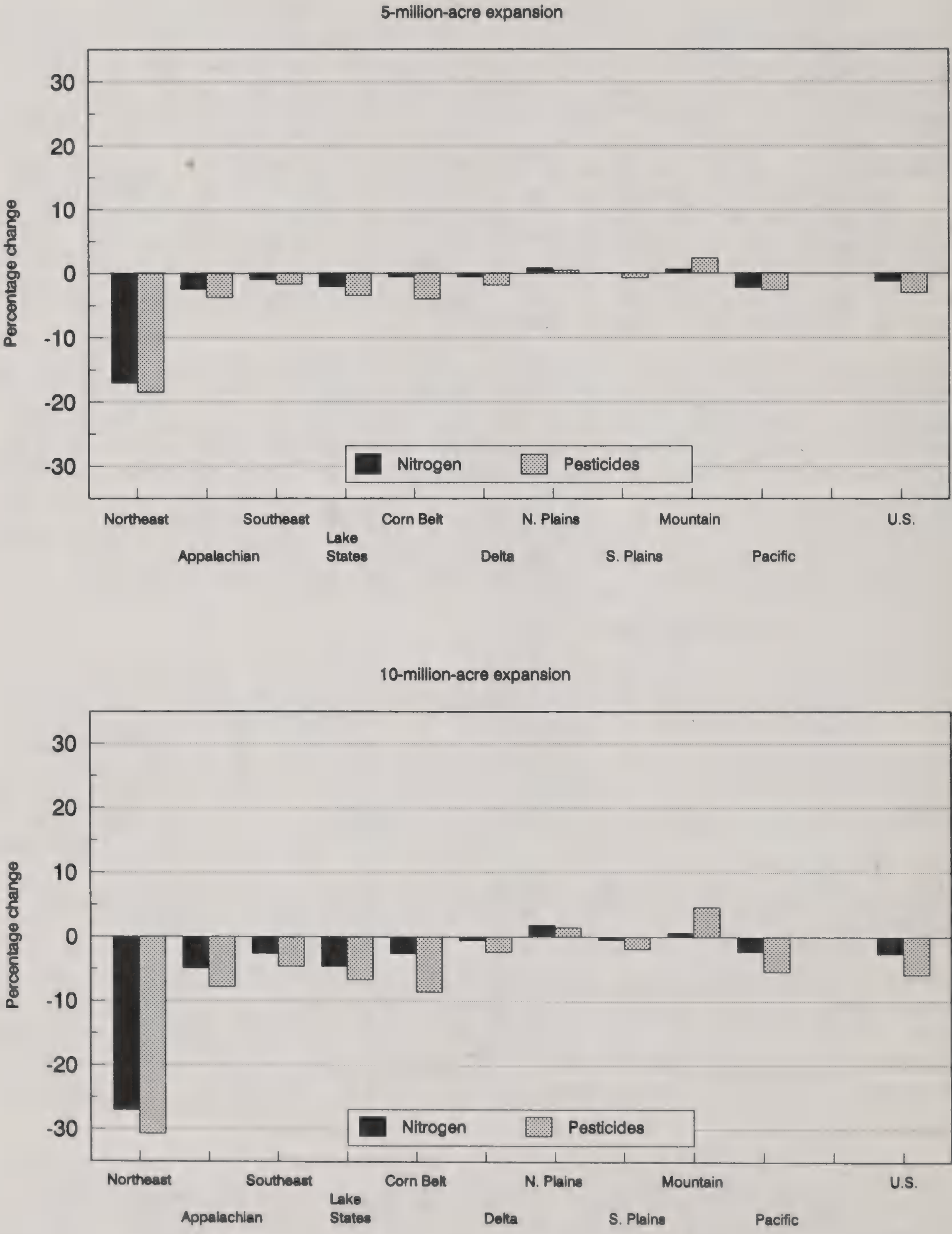
We assumed that 40 million acres would be enrolled in the existing CRP by the end of 1990.4/ Consequently, CRP expansion options of 5 million and 10 million acres imply total CRP enrollments of 45 million and 50 million acres. Signup opportunities for CRP expansions would take place from 1991 to 1995. As with the existing CRP, enrollment would be for a 10-year period, and it was assumed that use of forage on CRP acres would not be allowed. As with contract extensions, rental costs might be reduced by permitting selected commercial uses subject to environmental quality safeguards. Annual rental payments would be made to participating farmers and 50-percent cost-sharing for cover establishment would be provided. Eligibility rules would be redefined to target cropland causing the greatest surface-water quality problems.

Hypothetical CRP expansion enrollments were generated based on potential surface-water quality benefits from retirement of cropland not currently enrolled in the CRP (app. 2). National Resource Inventory (NRI) point erosion reductions (tons) were multiplied by estimates of per ton economic damages (Ribaudo, 1989) to provide acreage-specific benefit estimates. The 5 million

---

4/ Depending upon the actions of CRP program managers in conducting 1990 signups, enrollment under the existing CRP may not reach 40 million acres. If the 40-million-acre CRP enrollment level is not met, the crop production and ensuing economic effects of expansion/redirection would be less than reported.

Figure 15 -- Estimated regional effects of a CRP expansion on pesticide and nitrogen leaching potential



and 10 million acres with the greatest water quality benefits were then selected as candidates for targeted enrollment. Table 11 shows this acreage, targeted for maximum surface-water quality benefits, by region and by crop for the 5- and 10-million-acre CRP expansions. Most acreage is located in the Corn Belt, Northeast, and Lake States where the economic damages from nonpoint source pollution of surface water are large. This regional concentration results in a large percentage of corn acreage being targeted.

As the table indicates, although 5 and 10 million acres are initially targeted, net land retirements amount only to 3.9 million and 7.6 million acres, respectively. This slippage effect occurs because higher commodity prices resulting from the additional enrollment cause some additional crop planting.

Based on estimated rental payments for 10-year contracts and 50-percent cost-sharing for cover establishment, the direct government cost of the 5- and 10-million-acre CRP expansions were estimated to be $4.6 billion and $9.5 billion

Table 11—Estimated regional and major crop acreage distributions for CRP expansions targeted to surface-water quality: Initial targeting and net results

Item	5-million-acre expansion		10-million-acre expansion	
	Initial targeting	Net effect	Initial targeting	Net effect
	1,000 acres			
Region:				
Appalachian	- 560	- 546	-1,126	-1,101
Corn Belt	-1,160	-1,115	-2,831	-2,712
Delta States	- 287	- 259	- 522	- 468
Lake States	- 756	- 724	-1,564	-1,500
Mountain	- 3	55	- 25	87
Northeast	-1,741	-1,723	-2,690	-2,657
Northern Plains	- 16	914	- 86	1,841
Pacific	- 308	- 321	- 674	- 662
Southeast	- 130	- 123	- 339	- 324
Southern Plains	- 28	- 1	- 142	- 93
United States	-5,000	-3,850	-10,000	-7,600
	Percent change in planted acres compared with base 1/			
Crop:				
Soybeans	-1.8	-1.8	-4.0	-3.6
Corn	-4.3	-1.2	-8.0	-2.3
Wheat	- .7	- .9	-1.4	-1.7
Cotton	- .5	- .4	-1.4	- .9
Oats	-1.6	-4.6	-3.8	-7.7
Sorghum	- .5	-2.9	-1.1	-6.3
Barley	- .5	-1.5	-1.0	-2.9
Hay	- .5	-1.1	- .8	-2.2

Source: Agricultural Resources Model estimates.
1/ From baseline conditions.

in 1990 dollars, respectively. Annual rental payments averaging $90 per acre were based on county cash rents for targeted cropland, adjusted to account for continuing maintenance costs and other costs of CRP participation. This level is nearly twice the average annual rental cost for existing CRP land, reflecting the greater relative profitability of cropland targeted by a surface-water quality expansion. Cover establishment costs assume that most acres would be placed in grass cover and were based on existing CRP cost-share data.

As indicated, corn acreage accounted for nearly half of the acreage selected under both 5- and 10-million-acre CRP expansions. Even though the analysis assumed that this land would be initially retired from production in a CRP expansion, due to the relatively high value of corn and to resulting price increases, the net reduction in corn acreage is only about 25 percent of the amount targeted. This occurs because crop production shifts on remaining cropland and some additional land is brought into production. This moderates potential production, price, farm income, and government cost effects of the CRP expansions, but also lessens the potential improvement to surface-water quality. Net reductions in acreage by region and by crop are displayed along with the initially targeted acreage in table 11.

A 5-million-acre CRP expansion targeted to surface-water quality is estimated to increase the long-term equilibrium prices of crops by 1 to 5 percent (table 12). The prices of corn and wheat would increase by approximately 3 percent, while soybean prices would increase by about 1 percent. Total government deficiency and storage payments were estimated to decrease by 7 percent. An increase in farm income (not including contract rental payments) of less than 1 percent is also estimated to result from a 5-million-acre CRP expansion. These effects are all relative to a no-expansion baseline.

The economic effects resulting from a 10-million-acre expansion of course exceed those of a 5-million-acre expansion. Under the 10-million-acre scenario, commodity prices are estimated to increase by 3 to 9 percent, with corn, wheat, and soybean prices increasing by 5, 6, and 2 percent, respectively. Total government deficiency and storage payments are estimated

Table 12—Estimated changes in crop production and prices for CRP expansions targeted to surface water quality

Crop	5-million acre expansion		10-million acre expansion	
	Production	Price	Production	Price
	Percent change from base			
Soybeans	-1.4	1.2	-3.0	2.4
Corn	-1.0	2.6	-2.1	5.3
Wheat	-1.0	3.2	-2.0	6.3
Cotton	- .3	1.3	- .6	2.6
Oats	-5.0	5.1	-8.5	8.6
Sorghum	-3.5	2.8	-7.3	5.9
Barley	-1.8	4.1	-3.4	7.7

Source: Agricultural Resources Model estimates.

to decrease by 14 percent. Farm income is estimated to increase by a little more than 1 percent, again not including the new CRP rental payments. Surface-water quality benefits of the CRP expansions stem from reduced erosion and sediment delivery to streams, rivers, and lakes. Table 13 presents the regional distributions of benefits for the 5- and 10-million-acre expansion options. Annual surface-water quality benefits were estimated to average from $24 to $81 per acre for the 5-million-acre expansion and $18 to $59 per acre for the 10-million-acre expansion. This compares with estimated surface-water quality benefit ranges for the existing CRP of $4 to $12 per acre per year. The Northeast, Pacific, Corn Belt, and Lake State regions experience the greatest water quality benefits. Moreover, these benefits are net of water quality improvements expected as a result of enforcing the conservation compliance provision, while the existing CRP benefits are not.

Added potential wildlife hunting values due to expansions of the CRP were also estimated (app. 4). Assuming that new CRP acres increase wildlife habitat and animal populations, new hunters will begin hunting due to greater probability of success. Total estimated wildlife benefits through 2000 equaled $90.4 million and $175.8 million for the 5- and 10-million-acre expansions, respectively. This translates annually to about $2 per acre. These values do not include greater hunting by current hunters or nonconsumptive wildlife uses such as birdwatching.

Table 13—Estimated regional distributions of surface-water quality benefit from 5- and 10-million-acre expansions targeted to surface-water quality improvement

Region	Ranges for—1/ 5-million-acre option	Ranges for—1/ 10-million-acre option
	Million dollars 2/	
Appalachian	117 - 468	195 - 566
Corn Belt	150 - 611	267 - 956
Delta States	72 - 293	117 - 663
Lake States	130 - 507	202 - 605
Mountain	1 - 3	7 - 13
Northeast	267 - 1,060	371 - 1,242
Northern Plains	7 - 20	20 - 143
Pacific	234 - 930	449 - 1,398
Southeast	26 - 111	70 - 143
Southern Plains	7 - 20	20 - 65
United States	1,034 - 3,900	1,534 - 5,792

1/ Net if benefits provided by conservation compliance erosion reductions after 1994.
2/ 1991-2005 total, while agricultural policy has been trending toward a greater market.

The majority of wildlife benefits accrue to the Corn Belt, Southern Plains, and Lake States regions which exhibit high hunting participation rates and relatively high population bases. Whether the full benefits will be realized depends upon whether hunters are granted access to CRP land.

Finally, the CRP expansions would reduce the potential leaching of fertilizers and pesticides to ground-water resources. Figure 15 portrays these effects. Overall reductions in fertilizer and pesticide leaching in situations most likely to produce vulnerability were estimated at 2 and 5 percent for the 5- and 10-million-acre CRP expansions. The majority of this reduction occurs in the Northeast.

Longer Term Resource Adjustments in Agriculture

Almost all of the analyses reported share two important characteristics: agricultural commodity programs remain in place or are partially altered, and the input mix is not variable; that is, there is limited substitution. During 1991-95, the commodity program assumption may be appropriate, but adjustments in the long run may depart from those conditions. Since the 1985 Food Security Act, agricultural support prices have been trending down, base yields are frozen at 1986 program levels, and the Secretary of Agriculture has advocated international trade agreements that move toward greater market orientation, but complete program elimination is unlikely. But, in order to get a sense of the direction of changes in agricultural resource use, production, and prices under a market-oriented farm policy, we present a hypothetical case of complete program elimination. By presenting this case, the effect farm programs have had on agriculture is illustrated. The approaches presented in the other policy options are more short- to intermediate-run analyses in that there is a limited degree of substitution among inputs and outputs. The longer term case presented here permits complete substitution in production, given prevailing technology. To capture the possible long-term adjustments in agricultural resource use and environmental conditions without commodity programs, a different analysis has been conducted, which permits full input and output substitution (Shoemaker and others, 1989). In essence, the study is of unilateral commodity program reform in which government price stabilization and income support programs are eliminated along with associated land diversions. CRP land remains enrolled at 1985 FSA levels until contracts expire. The focus of the analysis is on the substitution between land and nonland inputs (for example, agrichemicals) as land prices readjust downward in the absence of government support payments.

The modeling procedure employs a computable general equilibrium (CGE) approach (Boyd, 1988) (app. 1). CGE models depict the longrun aggregate response of the agricultural and other sectors to external shocks such as commodity program elimination. The strength of a CGE model lies in showing aggregate national linkages among economic agents and producing sectors. It provides a mechanism for allowing all output and input quantities and prices to adjust to the policy shock. Moreover, it permits the systematic substitution of one class of inputs (land) for another (agrichemicals). One potential shortcoming shared by virtually all other models is an inability to capture induced technological change to the input and output price adjustments caused by the policy change.

Production and Price Effects

Two principal forces emerge from commodity program elimination in the short run that work in opposite directions. Removing price supports lowers the effective incentive prices to producers and should reduce production. However, the elimination of ARP's and paid land diversions increases the availability of land, leading to greater production potential. The net result depends upon the relative strength of each effect. In the long run, producers will adjust to lower incentive (commodity program) prices by substituting less expensive land for nonland inputs. Such a response, termed land extensification, would at least partially reverse the historical trend toward more intensive chemical and machinery use. Results from this analysis indicate that the cropland increase is insufficient to offset reduced incentive prices and that overall agricultural output will decline by about 2 percent.

This overall effect is composed of differential shifts in different crops and livestock. Program crop output is estimated to decline 6 percent, while nonprogram crops, such as hay, soybeans, alfalfa, and vegetables, increase by 1 percent. Livestock output falls by less than 2 percent. Market prices are estimated to increase 6 and 11 percent for livestock and program crops, respectively. Nonprogram crop prices are projected to fall by about 3 percent.

Input Adjustments

To the extent that nonland inputs are substitutable with land, commodity programs, by restricting land availability, have encouraged greater use of nonland inputs. The increase in available land and overall decline in production is estimated to decrease both labor and capital by 5.5 percent and agrichemical use by 8 percent. Fertilizers and pesticides decline by 12 and 8 percent for program crops, but only by 5 percent for nonprogram crops.

An important input adjustment is land allocation and valuation. Due to the elimination of land diversions, overall land used in crop production rises 4 percent. However, longrun equilibrium land rents fall by 16 percent due to increased land availability and reduced agricultural support payments for crops. Because agriculture is not a primary user of labor and capital relative to the rest of the economy, their prices are unaffected by commodity program elimination.

Income

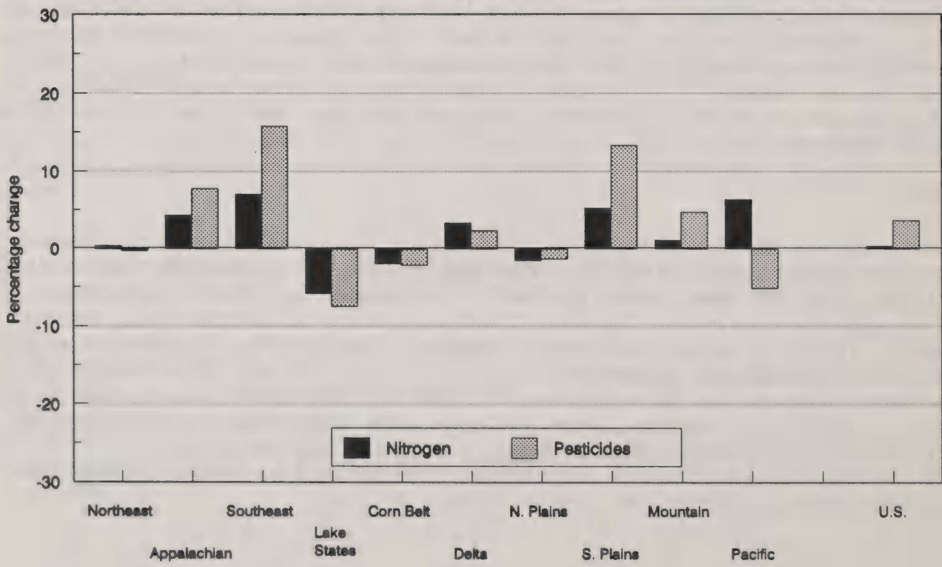
Total income to the farm sector is measured as the payments to farmer-owned factors of production. With the exception of land, the quantities of capital and labor used declined, reducing their total payments. Land use increases but its earnings decline. The net effect is that total income falls roughly 8 percent. In 1988, direct government payments accounted for 32 percent of net farm income. Thus in the long run, farmers recover all but 8 percent of lost government payments due to adjustments in production. The loss in land values due to policy reform implies there would be some financial restructuring of the farm sector. Farmers with stronger balance sheets would acquire land from those in financially stressed situations. Declining farm numbers imply that after adjustments, income per farm may actually rise.

Environmental Effects

The projected changes in agricultural output and input structure also translate into different environmental conditions related to agriculture. Nationally, the output shifts and land reallocation is estimated to reduce erosion by about 3 percent. This result must be qualified, however, since Conservation Compliance and Sodbuster incentives will also be eliminated. If those provisions prove very effective in reducing erosion, then program elimination could cause increased erosion. On the other hand, if they are ineffective due to declining program support levels, the net erosion effect of program elimination is uncertain. Assuming a 3-percent reduction is accurate, then annual surface-water quality benefits in the range of $30 million to $150 million could be expected. The greatest benefits are estimated to occur in the Corn Belt and Lake States. Note that program elimination would also remove any incentives to comply with the Swampbuster provision, with consequent implications for the conversion of wetlands.

Perhaps the most important environmental effect of program elimination is the reduction in agrichemical use spread over a larger land base. This land extensification process should diminish the general possibility of agrichemical damages to the environment by reducing average per acre loadings given the assumptions regarding input substitution. Moreover, these estimated decreased application rates do not fully incorporate the added fertility and pest control benefits of more diversified crop rotations. Neilsen and Lee estimate that areas with pesticide and/or nitrate contamination potential are cropped intensively, with 33 percent of land in crop production, compared with 16 percent nationally. Since 70 percent of that crop acreage is corn, soybeans, and wheat, any decrease in incentives to use agrichemicals could improve ground-water quality overall. Analysis of the regional composition of agrichemical adjustments in 1993 shows differential effects in figure 16 (app.

Figure 16 -- Estimated regional effects of policy elimination on pesticide and nitrogen leaching potential for 1993



3). The greatest potential improvements are in the Lake, Corn Belt, and Northern Plains regions. In contrast, vulnerability increased in the Southern Plains, Southeast, and Appalachian areas due to changes in crop composition and input use. Despite a decrease in national quantities of fertilizers and pesticides, the changes in use are distributed over different vulnerability conditions such that pesticide leaching potential in highly vulnerable situations is estimated to increase.

Effects on the Rest of the Economy and Government Spending

Effects in the agricultural markets have further implications for the rest of the economy. While the agricultural sector itself represents only a small percentage of the total output of the economy, removal of farm programs and the resulting effect on farm sector output, prices, and inputs will have effects on other sectors of the economy. Changes in the prices of agricultural commodities relative to the prices of other goods cause a change in the demand by consumers. Inputs formerly used in agriculture will be used in producing other goods. The increase in available farmland and elimination of target prices will encourage labor and capital to migrate into other sectors of the economy. In addition, any resulting changes in food costs could have important implications for individuals in different income classes.

Lower government costs for supporting incentive prices coupled with lower market prices for nonprogram crops increase consumer welfare, but the gains are partially offset by higher market prices for program crops and livestock. Consumers in the lowest income categories spending a larger percentage of their incomes on food are potentially made worse off than consumers in higher income brackets. Therefore, higher food costs impose a larger burden on individuals in lower income categories. In general, the cost of eliminating commodity programs to consumers is small relative to the gain in revenue to the government. The net effect on consumer welfare depends on how and if the government redistributes the revenue generated by eliminating commodity programs. We assume that the additional revenue will be redistributed to consumers in a lump sum fashion with payments to each consumer category based on the number of households. The overall benefits in terms of economic efficiency gains and reduced tax burdens provide a means to compensate individuals and make everyone better off with the elimination of farm programs. In a somewhat different vein, Feltenstein estimated that eliminating U.S. farm programs over 1985-86 would have saved an additional $16 billion over the $58 billion in direct budget outlays through its effect on interest rates and tax rates. Results from our analysis suggest that for 1984 the Federal Government spent almost $10 billion in order to protect a potential loss of $6 billion in farm returns.

Notes on Problems in Coordinating Agricultural and Environmental Policies

The analysis reveals that the two policy approaches are not independent. That is, the net environmental and economic effects of land retirement depend on assumed commodity program operation and vice versa.

The effects of a CRP redirection or wetland reserve can be estimated if commodity provisions are assumed constant. However, if the commodity provisions, such as ARP levels, are relaxed as enrollment proceeds, the net economic and environmental effects are indeterminate. The net economic effects ultimately depend on the level of ARP relaxation and effects on

aggregate production and price. An important question is the relative cost effectiveness of ARP versus wetland or CRP acres in controlling supply. But the net environmental effect depends on the unknown environmental benefits on ARP lands which are foregone if the ARP percentages are lowered. A targeted CRP redirection or wetland reserve should presumably provide greater environmental benefits than average ARP acres.

Economic and environmental effects of altering commodity program provisions, such as increased planting flexibility, also depend on conservation land use change or retirement. For example, a larger CRP enrollment which disproportionately affects the production of one crop more than another, such as wheat versus corn, will affect the relative market incentives that farmers view on flexible acres. Farmers' ultimate cropping decisions in turn determine the changes in agrichemical use, erosion, and other environmental values. Because of these interdependencies, the analyses are carried out in comparison with a single set of baseline conditions, but sight should not be lost of these important interrelationships.

Finally, the analyses must be conducted under an assumed set of baseline assumptions characterizing average expected conditions. Of course, events projected incorrectly or not amenable to projection will produce different results. Judging how the policy approaches here would perform under varying external conditions is a worthwhile exercise. For example, what if the early 1970's export boom and price rise occur again? The economic and environmental effects of planting flexibility would be determined by the set of market prices emerging from that boom. If a chemically intensive crop, such as corn, experiences greater price rises than those requiring less chemicals, the agrichemical changes reported here could be reversed. Another example is a shift in consumer demand to foods grown with low or no pesticide applications. Such a shift would enhance the environmental movements predicted here. The important lesson is that measures to address environmental problems through cropping choices may be thwarted because the basic environmental externality causes remain.

References

1. Agricultural Policy Working Group (APWG). Agricultural Policy for the 1990's. Washington, DC, June 1989.

2. Aller, L. and others (National Water Well Association). DRASTIC: A Standardized System for Evaluating Ground Water Pollution Potential Using Hydrogeologic Settings. Ada, OK: U.S. Environmental Protection Agency, Robert S. Kerr Environmental Research Laboratory, EPA/600/2 - 85/018, May 1985.

3. Amacher, G.S., R.J. Brazee, J.W. Bulkley, and R.W. Moll. An Interdisciplinary Approach to Valuation of Michigan Coastal Wetlands. University of Michigan, School of Natural Resources, Ann Arbor, 1988.

4. Berner, Alfred H. "Federal Land Retirement Programs: A Land Management Albatross." paper presented at the Transactions North American Wildlife and Natural Resources Conference, 1984. pp. 118-131.

5. The 1985 Farm Act and Its Implications for Wildlife. Conservation Challenges, 1989.

6. Boyd, R. An Economic Model of Direct and Indirect Effects of Tax Reform on Agriculture. TB-1743. U.S. Dept. Agr., Econ. Res. Serv., Feb. 1988.

7. Brown, Gardner, and Michael J. Hay. "Net Economic Recreation Values for Deer and Waterfowl Hunting and Trout Fishing, 1980." Working paper No. 23. U.S. Fish and Wildlife Service, Division of Directives Management, 1987.

8. Cacek, T. "After the CRP Contract Expires," Journal of Soil and Water Conservation. Vol. 43, No. 4, 1988. pp. 291-293.

9. Clark, E.H., II, J.A. Haverkamp, and W. Chapman. Eroding Soils: The Off-Farm Impacts. Washington, DC: The Conservation Foundation, 1985.

10. Conservation Foundation. Protecting America's Wetlands: An Action Agenda. The final report of the National Wetlands Policy Forum. Washington, DC, 1988.

11. Daberkow, Stan, and Katherine H. Reichelderfer. "Low-Input Agriculture: Trends, Goals, and Prospects for Input Use," American Journal of Agricultural Economics. Vol. 70, No. 5, 1988. pp. 1159-1166.

12. Daberkow, Stan, and Mohinder Gill. "Common Crop Rotations Among Major Field Crops," Agricultural Resources, Situation and Outlook Report. U.S. Dept. Agr., Econ. Res. Serv., Aug. 1989. pp. 34-39.

13. Dicks, Michael R., Felix Llacuna, and Michael Linsenbigler. The Conservation Reserve Program: Implementation and Accomplishments, 1986-87. SB-763. U.S. Dept. Agr., Econ. Res. Serv., Jan. 1988.

14. Duebbert, Harold F. "High Nest Density and Hatching Success of Ducks on South Dakota Cropland Adjustment Program Land." Transactions North American Wildlife and Natural Resources Conference. Vol 34, 1969. pp. 218-228.

15. Duffy, Michael, and Craig A. Chase. Impacts of the 1985 Food Security Act on Crop Rotations and Fertilizer Use. Department of Economics, Iowa State University, Ames, 1989.

16. Ek, C. Normal Crop Acreage. 89-467 ENR. Congressional Research Service, Aug. 14, 1989.

17. Erikson, Ronald E., and J.E. Wieve. "Pheasants, Economics and Land Retirement Programs in South Dakota," Wildlife Society Bulletin. Vol 1, No. 1, 1973. pp. 22-27.

18. Evans, S. "Acreage Response to the Target Price and Set-Aside Provisions of the Food and Agriculture Act of 1977," Agricultural Economic Research. Vol. 32, No. 4, Oct. 1980.

19. Feltenstein, Andrew. "Agricultural Policies and the U.S. Federal Budget and U.S. Trade Deficit," Macroeconomic Consequences of Farm Support Policies. 1989. pp. 200-221.

20. Fleming, Malcolm H. "Agricultural Chemicals in Ground Water: Preventing Contamination by Removing Barriers Against Low-Input Farm Management,"

American Journal of Alternative Agriculture. Vol. 2, No. 3, 1987. pp. 124-130.

21. Floyd, J.E. "The Effects of Farm Price Supports on the Returns to Land and Labor in Agriculture," Journal of Political Economy. Vol. 73, No. 2, Apr. 1965. pp. 148-155.

22. Frerichs, Stephen. "Commodity Programs, Rotations and Planting Flexibility." unpublished draft paper. U.S. Dept. Agr., Econ. Res. Serv.

23. General Accounting Office. Farm Programs: Conservation Reserve Program Could Be Less Costly and More Effective. GAO/RCED-90-13. Nov. 1989.

24. Gianessi, L.P., H.M. Peskin, and C. Puffer. A National Data Base of Nonurban Nonpoint Source Discharges and their Effect on the Nation's Water Quality. Resources for the Future, Washington, DC, 1985.

25. Gianessi, L., and C. Puffer. Use of Selected Pesticides in Agricultural Crop Production by State. Use Coefficients Listed by Active Ingredient. Resources for the Future, Washington, DC, Apr. 1988.

26. Goss, D.W. "Soil and Pesticide Information for Implementing Water Quality." unpublished. National Soil Survey Center, U.S. Dept. Agr., Soil Conservation Service, Lincoln, NE, 1989.

27. Gustafson, D.I. "Groundwater Ubiquity Score: A Simple Method for Assessing Pesticide Leachability," Environmental Toxicology and Chemistry. Vol 8, 1989. pp. 339-357.

28. Harmon, Keith W., and Maynard M. Nelson. "Wildlife and Soil Considerations in Land Retirement Programs," Wildlife Society Bulletin. Vol. 1, No. 1, 1973. pp. 28-38.

29. Hay, Michael J. "Net Economic Recreation Values for Deer, Elk and Waterfowl Hunting and Bass Fishing, 1985." Working Paper 85-1. Division of Policy Directives Management, U.S. Fish and Wildlife Service, 1988.

30. Hay, Michael J., and Kenneth E. McConnell. "Hunting and Nonconsumptive Wildlife Recreation Decisions," Land Economies. Vol. 60, 1984. pp. 388-396.

31. Heady, Earl. "The Economics of Rotations with Farm and Production Policy Applications," Journal of Farm Economics. Vol. 3014, 1948. pp. 645-664

32. Heimlich, R.E. "An Agricultural Wetland Reserve: Creating Wetlands from Drained Cropland." paper presented at American Agricultural Economics Association Meetings, Baton Rouge, LA, July 30 - Aug, 2, 1989. U.S. Dept. Agr., Econ. Res. Serv.

33. Heimlich, R.E., M.B. Carey, and R.J. Brazee. "Beyond Swampbuster: A Permanent Wetland Reserve," Journal of Soil and Water Conservation. Sept.-Oct. 1989.

34. Heimlich, R.E., and O.E. Kula. "Grasslands: The Future of CRP Land After Contracts Expire," Journal of Production Agriculture. Forthcoming.

35. Heimlich, R.E., and L.L. Langner. Swampbusting: Wetland Conversion and Farm Programs. AER-551. U.S. Dept. Agr., Econ. Res. Serv., Aug. 1986.

36. Heimlich, R.E., J. Wrona, S. Felder, K. Krupa, J. Schwein, and P. Smith (contributors). "Grazing Lands and the Conservation Reserve Program." paper presented at the Grazing Lands Forum, third forum, Harpers Ferry, WV, 1989. U.S. Dept. Agr., Econ. Res. Serv.

37. Holmes, T.P. "The Offsite Impact of Soil Erosion on the Water Treatment Industry," Land Economics. Vol. 64, No. 4, 1988. pp. 356-366.

38. Hrubovcak, J., R. Shoemaker, and M. Anderson. "U.S. Commodity Programs, Agricultural Procedure, and Resource Use." forthcoming. U.S. Dept. Agr., Econ. Res. Serv.

39. Hrubovcak, J., M. LeBlanc, and J. Miranowski. "Limitations in Evaluating Environmental and Agricultural Policy Coordination Benefits," The American Economic Review. Vol. 80, No. 2, 1990. pp. 208-212.

40. Johnston, George M. "Wildlife and Agriculture: A Case of Interdependence, Emerging Policy Issues." Cooperative Extension Service, Michigan State University, East Lansing, 1984.

41. Konyar, K.E., C. McCormick, and M. Carey. "An Economic Model of Government Programs and Regional Resource Use." forthcoming. U.S. Dept. Agr., Econ. Res. Serv.

42. Langley, J.A., R.D. Reinsel, J.A. Craven, J.A. Zellner, and F.J. Nelson. "Commodity Price and Income Support Policies in Perspective," Agricultural-Food Policy Review: Commodity Program Perspectives. AER-530. U.S. Dept. Agr., Econ. Res. Serv., July 1985.

43. Langner, Linda. "Land Use Changes and Hunter Participation: The Case of the Conservation Reserve Program." paper presented at the North American Wildlife and Natural Resources Conference, Mar. 1989.

44. McCormick, I., and K. Konyar. "Implications of Increased Program Planting Flexibility for Agricultural Resource Use." forthcoming. U.S. Dept. Agr., Econ. Res. Serv.

45. Miller, Jon R., and Michael J. Hay. "Determinants of Hunter Participation: Duck Hunting in the Mississippi Flyway," American Journal of Agricultural Economics. Vol. 63, No. 4, 1981. pp. 677-684.

46. Miranowski, J.A. "The Demand for Agricultural Crop Chemicals Under Alternative Farm Program and Pollution Control Solutions." unpublished Ph.D thesis. Harvard University, Cambridge, MA, May 1975.

47. Miranowski, J., J. Hrubovcak, and J. Sutton. "The Effects of Commodity Programs in Reserve Use." paper presented to the Commercial Agricultural and Reserve Policy (CARP) symposium. Baltimore, MD, May 4-5, 1989. U.S. Dept. Agr., Econ. Res. Serv.

48. National Research Council. "Committee on the Role of Alternative Farming Methods in Modern Production Agriculture," Alternative Agriculture. National Academy Press, Washington, DC, 1989.

49. Nielsen, E.G. and L.K. Lee. The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals: A National Perspective. AER-576. U.S. Dept. Agr., Econ. Res. Serv., Oct. 1987.

50. Osborn, C. Tim, Felix Llacuna, and Michael Linsenbigler. The Conservation Reserve Program: Enrollment Statistics for 1987-88 and Signup Periods 1-7. SB-785. U.S. Dept. Agr., Econ. Res. Serv., Sept. 1989.

51. Powell, J.F. "Legumes: Their Potential Role in Agricultural Production," American Journal of Alternative Agriculture. Vol. II, No. 2, Spring 1987.

52. Reichelderfer, K.H. Do USDA Farm Program Participants Contribute to Soil Erosion? AER-532. U.S. Dept. Agr., Econ. Res. Serv., Apr. 1985.

53. Ribaudo, M. Water Quality Benefits of the Conservation Reserve Program. AER-606. U.S. Dept. Agr., Econ. Res. Serv., 1989.

54. Rutherford, Thomas. "A Modeling System For Applied General Equilibrium Analysis." Cowles working paper, Yale University, 1987.

55. Shabman, L.A., and S.S. Batie. Socioeconomic Functions and Values of Wetlands: A State-of-the-Art Review. Technical Report Y-85. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, 1985.

56. Shoemaker, R., M. Anderson, and J. Hrubovcak. "U.S. Farm Programs and Agricultural Resources." AIB-614. U.S. Dept. Agr., Econ. Res. Serv., Sept. 1990.

57. Shoemaker, R., M. Anderson, and J. Hrubovcak. "From the 1985 Farm Bill to 1990 and Beyond: The Resource Effects of Commodity Programs," Agricultural Reserve Cropland, Water and Conservation, Situation Outlook. AR-16. U.S. Dept. Agr., Econ. Res. Serv., Sept. 1989.

58. Sorg, Cindy F., and John B. Loomis. Empirical Estimates of Amenity Forest Values: A Comparative Review. General Technical Report RM-107. U.S. Dept. Agr., Forest Service, 1984.

59. Tisdale, S.L., Nelson, W.L., and J.D. Beaton. Soil Fertility and Fertilizers. Fourth Ed., New York: Macmillan Publishing Company, 1985.

60. U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. "Summary of 1988 Preliminary Enrollment Report." News release 649, 1988.

61. U.S. Department of Agriculture, Economic Research Service. Agricultural Resources: Inputs, Situation and Outlook. AR-15. Aug. 1989.

62. Walsh, Richard G., and others. Wildlife and Fish Use Assessment: Long Run Forecasts of Participation in Fishing, Hunting and Non-Consumptive Wildlife Recreation. Technical Report No. 50. Colorado State University, Dec. 1987.

63. Walsh, Richard G. and others. A Comparison of Long Run Forecasts of Demand for Fishing Hunting and Non-Consumptive Wildlife Recreation Based

on the 1980 and 1985 National Surveys. Technical Report No. 55, Colorado State University, Dec. 1988.

64. Young, C., Edwin, C. Tim Osborn (editors). "The Conservation Reserve Program: An Economic Assessment." AER-626. U.S. Dept. of Agr., Econ. Res. Serv. 1990.

Appendix 1--Analysis Procedures: Estimation of Production, Price, Crop Mix, Chemical Use, Farm Income, and Budgetary Effects

This appendix describes the two models used in the economic analysis. The first is the U.S. Agricultural Resources Model, which determines regional changes in production patterns. The second is a CGE model, which estimates the fully adjusted longrun economy under policy effects.

Description of U.S. Agricultural Resources Model (USARM)

To capture the effects of planting flexibility on production patterns, value of production, chemical use, farm income and the budget, a nonlinear programming model developed by the USDA Economic Research Service is used (Konyar, McCormick, and Carey, forthcoming). Given the regional variability of environmental conditions and the intricate nature of farm programs, the programming approach seemed the most appropriate method.

The model produces conditional near-term estimates within a partial equilibrium, comparative static framework. Regional allocation of land among crops, commodity program participation, and irrigated/dryland production decisions represent the endogenous decision variables. Each activity has a positively sloping supply curve at the regional level, imposing decreasing returns as activity levels increase. Crop prices are endogenous via negatively slopping demand curves at the national level. The objective function maximizes the area between the linear demand and supply curves, analogous to solving a competitive equilibrium problem.

The model includes all the major commodity program provisions and allocates production among 23 regions (17 Western States and the 6 eastern USDA production regions) and 9 major crops (barley, oats, sorghum, corn, wheat, cotton, rice, soybeans, and hay). The model calibrates to 1987 as the base and is solved using a nonlinear optimization package, GAMS/MINOS. For the purpose of this study, a baseline reflecting projections for the 1990 crop year is developed. This allows for a static comparative analysis of the policy alternatives given expected conditions for initial crop levels, commodity program provisions (for example, target prices, ARP rates, and loan rates), and acreage available for production.

For each planting flexibility design option, the model develops estimates for the number of acres allocated to each activity, crop prices, value of production, aggregate chemical use, farm income, and direct government costs. The results are compared with baseline and presented as the percentage changes from the estimated 1990 levels. The estimated effects should be interpreted as values after the sector adjusts to the policy changes, about 1 to 3 years.

Description of Computable General Equilibrium

The general underlying structure of the model has been described in sufficient detail elsewhere so that only a brief overview is required.1/ The economy is divided into 12 production sectors: manufacturing, mining, services, chemicals and plastics, food and tobacco processing, petroleum refining, financial, forestry, crude oil and natural gas, agricultural program crops,

---

1/ The model structure used in this analysis was initially developed by Boyd and employs a modeling framework developed by Rutherford.

agricultural nonprogram crops, and livestock. Outputs from the producing sectors are used directly by the government, for export, or in other producing sectors. Production goods also pass though a transition matrix in order to be converted to consumer goods for final sale. Consumer goods include food, alcohol, and tobacco; utilities; furnishings and appliances; clothing and jewelry; transportation; motor vehicles; financial and other services; reading and recreation; nondurable household items; gasoline and other fuels; and savings.

A government sector purchases private goods and supplies public goods as well as transfers some tax collections back into the economy. Increases in Federal revenues from reduced commodity program costs when programs are eliminated are passed back into the general economy through lump sum transfer payments or increased production of public goods. A foreign sector is included to close the model by adding a foreign consumer. U.S. exports (foreign demand) and U.S. imports (foreign supply) are delineated by producing sector. The exports and imports are then scaled so that the total foreign account is balanced.

Initially, households in each of six income categories hold all primary inputs (land, labor, capital). For a given set of economic conditions, each household then employs a multistage budgeting process, deciding how much labor to supply at the prevailing wage rate and choosing between current and future consumption. Utility takes the form of a nested constant elasticity of substitution (CES) function. Any change in relative food prices when farm programs are eliminated alter both the labor/leisure and consumption/savings decisions as well as the relative demands for consumer goods. Producers bid for primary inputs as well as inputs from other producing sectors based on relative marginal products and output prices. Sectoral production technologies are also depicted by a nested CES framework.

Finally, in order to ensure equilibrium and data consistency, the following four conditions are imposed: household income equals the value of expenditures (including savings), government income equals the value of outlays, the value of market demand equals value added plus taxes, and the values of exports equals the value of imports (Rutherford).

Eliminating Government Support

Agricultural support is eliminated by introducing a tax on agricultural output. Tax rates are set at levels which would eliminate the benefits from deficiency payments, marketing quotas, and irrigation subsidies. The appropriate tax rate for each of the agricultural sectors is based on producer subsidy equivalents (PSE's).2/ Estimates of these subsidies have been developed by USDA and then aggregated to be consistent with the agricultural subsectors in our model.3/ Based on the PSE's for 1984, a 13- and 7-percent

---

2/ PSE's measure the importance of government policy in terms of their contribution of producer revenues. For a more complete definition of PSE's, see Estimates of Producer and Consumer Subsidy Equivalents: Government Intervention in Agriculture, 1982-86, U.S. Department of Agriculture, Economic Research Service, Staff Report AGES 880127, Apr. 1988.

3/ The model disaggregates the farm sector into program crops, nonprogram crops, and livestock. The disaggregation limits some analysis because there may be considerable variation within subsectors of the farm economy. For

unit output tax is then introduced into the model for program crops and livestock, respectively, in order to represent elimination of program benefits.

For 1984, under the ARP, farmers were required to set aside 10 percent of base acreage for barley, corn, oats, and sorghum; 20 percent for wheat; and 25 percent for cotton and rice. Nationally, over 27 million acres were set-aside in the ARP in 1984, representing over 8 percent of total cropland harvested. Converting these acres to value, the total value of the land endowment (which includes cropland, rangeland and pasture, and forest) is increased by 4 percent in order to represent removal of the ARP. While this may appear high in relation to the total land base, in value terms, rangeland, pasture, and forest land are significantly lower than cropland.

---

example, livestock contains both beef and dairy. Dairy has received more protection than has beef. Without a more detailed agricultural sector, it is difficult to capture the movement of resources within a subsector of the farm economy.

Appendix 2--Surface-Water Quality Benefits Estimation Procedures

The procedures used to estimate the water quality benefits from reduced erosion on cropland are described in Ribaudo (1989). In brief, the procedures were developed to estimate changes in consumer surplus for recreational fishing, changes in defensive expenditures for water navigation, flooding, municipal water use, and ditches, and changes in production costs for industrial water use and municipal water treatment.

Before economic effects could be fully assessed, changes in water quality from the changes in erosion due to the CRP had to be estimated. For each of the 99 aggregated sub-areas (ASA) (large river basins), the changes in erosion from retiring 5 million and 10 million acres of cropland were estimated with data from the 1982 NRI. Reduced soil erosion and fertilizer use affect the amounts of sediment and nutrients discharged into waterways. Data on sediment and nutrient delivery ratios had been developed by Resources for the Future for each ASA (Gianessi, Peskin, and Puffer, 1985). Multiplying the change in erosion and cropland acreage in each ASA by the sediment and nutrient delivery ratios resulted in changes in the amount of sediment, nitrogen, and phosphorus reaching waterways.

The changes in sediment and nutrient discharge result in changes in water quality. These changes were quantified with water quality models for sediment, nitrogen, and phosphorus estimated with data from the U.S. Geological Survey's NASQUAN water quality monitoring system (Resources for the Future (Gianessi, Peskin, and Puffer, 1985), and the Water Resources Council (Ribaudo, 1989)). With these models, it was possible to estimate changes in concentrations of suspended sediment, nitrogen, and phosphorus given the changes in discharge for each of the 99 ASA's.

The changes in ambient water quality were needed in estimating the benefits to recreational fishing and water treatment. For recreational fishing, a behavioral model describing the probability of fishing and the level of participation as a function of water quality and socioeconomic variables was used to estimate changes in total fishing participation for each farm production region FPR. This model was estimated with data largely from the 1980 Survey of Hunting, Fishing, and Wildlife-Associated Recreation and NASQUAN. Average consumer surplus from fishing derived from the literature were applied to the changes in participation to reach an estimate of benefits (Sorg and Loomis, 1984).

For water treatment, Holmes' water treatment cost model was used to estimate benefits to the water treatment industry. Holmes' model specifies a water treatment plant's costs as a function of suspended sediment and other production variables. Changes in suspended sediment estimated with the water quality model were applied to the results of Holmes' model to derive changes in treatment costs for each ASA. Avoided treatment costs are equivalent to benefits.

Benefits from reduced flooding, reduced reservoir sedimentation, reduced water use costs, and reduced dredging were all assumed to be directly related to reductions in sediment discharge, for lack of specific damage functions. Damages per ton of sediment discharged for each damage category were estimated for each FPR (Ribaudo, 1989). These unit estimates were then applied to the reduction in sediment discharge in each FPR. The resulting reductions in damages were assumed to be equivalent to benefits.

Benefits from reduced roadside and irrigation ditch maintenance costs were assumed to be directly related to reductions in erosion. Damages per ton of erosion were first estimated for each FPR (Ribaudo, 1989). Changes in erosion due to the CRP expansion were then multiplied by the unit damages to arrive at an estimate of reduced maintenance costs, or equivalently, benefits.

A range of benefits/costs was calculated for each water use category, rather than a point estimate. The range reflects our best estimate of the likely bounds of the benefits/costs estimates. The range is based on statistical estimates (95-percent confidence interval) or on observation (Clark, Haverkamp, and Chapman, 1985), depending on the information available. A range rather than a point estimate is presented because the estimated economic effects from the policy options rest on many assumptions, which may have caused overestimation or underestimation. Assumptions had to be made about the links between soil erosion and economic effects on water users. These included premises about the relationships between erosion and lake water quality, and about the effectiveness of defensive expenditures. Any inferences about the overall value of the options, therefore, should be based on the range of water quality effects computed.

The benefits calculated above could be considered the primary effects from CRP expansion. However, after the land is retired, secondary effects occur. These consist of additional water quality effects due to changes in crop mix and additional land coming into production from fallow, resulting from a restricted land base and changes in crop prices. One result of this is a net decrease in crop acreage that is something less than the additional land enrolled in the CRP. The change in the crop mix and production on formerly fallow land tends to increase erosion on these acres, and thus lessens the water quality benefits from CRP expansion.

To calculate the changes in crop acreage due to changes in prices and the land base, the additional CRP acreage was first allocated among program crops on the basis of the acreage distribution in the baseline scenario. The results were then subtracted from the baseline, and compared with the post-CRP crop acreage estimated with the ARM model. Differences were assumed to be due to price and resource changes.

Changes in erosion were estimated on a program crop basis for each FRP. Change in crop acreage was multiplied by the difference between the average erosion rate for that crop in that region (from the 1982 NRI) and the average erosion rate for hay. Total changes in erosion in each FPR were then multiplied by the per ton damages previously estimated by Ribaudo (1989). These results were then subtracted from the primary benefits.

A simplified procedure was used to estimate the water quality benefits for the other policy options (planting flexibility, base limitation, wetland reserve, and program elimination). A direct relationship between erosion and damages was assumed. The major reason for making this assumption was that the geographic detail was insufficient to use some of the benefits/damage models. For each FPR, damages per ton of erosion for all categories (recreation, water use, water treatment, flooding, navigation, and ditches) were calculated (from Ribaudo, 1989). These estimates were applied to the estimated changes in erosion due to the policy option for each FPR. In general, the unit damage approach assumes that surface-water benefits are a linear function of the erosion, sediment, and fertilizer reductions. Increases in erosion resulted

in additional damages; decreases in erosion resulted in benefits.

Changes in erosion were estimated on a program crop basis for each FPR. For each policy analysis, acreage in each program crop (including soybeans) in each region prior to the policy option was established as a baseline.4/ Total erosion for the baseline was then calculated using average erosion rates by crop, calculated with data from the 1982 NRI. Changes in erosion on the land in program crops in the baseline were then determined for each policy scenario, based on estimated acreage changes. If total program crop acreage decreased, it was assumed that the land retired went into hay. If program crop acreage increased, it was assumed that the land coming into production had been in hay. The 1982 NRI erosion rates for each crop in each region were again used to estimate changes in erosion.

Changes in erosion in each FPR were then multiplied by the per ton damages previously estimated. The results were the surface-water quality benefits or costs from the policy option.

4/ Program crop acreage for the various baseline was around 290 million acres. Erosion on this land was about 80 percent of cropland erosion reported in the 1982 NRI minus annual reductions estimated for the CRP (assuming 35 million acres enrolled).

Appendix 3--Estimating Leaching Potential from Pesticide and Nitrogen Fertilizer Use

The potential for fertilizers and pesticides to accumulate in ground water depends on a combination of environmental and human factors. Local site characteristics, such as climate, soil type, topography, depth to ground water, and the hydrogeologic properties of the aquifer are important factors in determining the susceptibility of ground water to leached agrichemicals. In general, areas where chemical leaching may present a risk to ground-water quality have sandy, highly permeable soils low in organic matter, receive enough rainfall or irrigation to promote leaching, and are located over shallow, unconfined aquifers. In addition to these site characteristics, agrichemical use practices on the farm are also important factors in determining the potential for residues to reach the ground water. The method, rate, and timing of applications, as well as the physicochemical properties of the materials used, are among the most important management-related factors influencing the ultimate fate of agricultural chemicals in the environment.

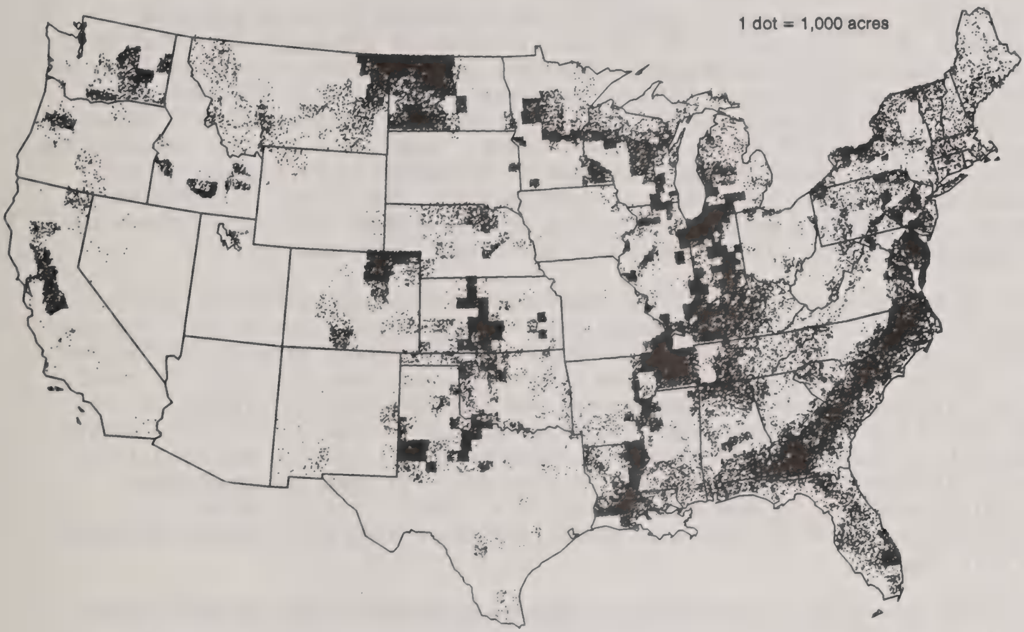
A methodology was developed that incorporates these factors into a regional framework for assessing the effectiveness of various policy proposals in reducing the risk of ground-water contamination. The resulting model estimates the potential for leaching which arises from the use of pesticides and nitrogen fertilizers on the major commodities: corn, sorghum, wheat, barley, oats, cotton, rice, peanuts, tobacco, soybeans, and hay. The model is capable of predicting the changes in leaching potential which may result from: (1) regional shifts in crop production, (2) changes in the intensity of pesticide and nitrogen use, and (3) removal of certain land or soil groups from production for each of the 10 USDA production regions. The model is calibrated to represent county-level crop production in 1987, as reported by the 1987 Census of Agriculture.

State-level estimates of pesticide and nitrogen fertilizer use were compiled for each crop from information collected by ERS (the Objective Yield Survey and the Farm Costs and Returns Survey) and a national pesticide use survey compiled by Resources for the Future (Gianessi and Puffer, 1988). Total nitrogen fertilizer use in each county was estimated on the basis of the number of harvested crop acres, yielding total pounds of nitrogen applied. The resulting total was then multiplied by a factor (ranging from 0 to 1) which reflects the relative hydrogeologic vulnerability of the county, as estimated by the DRASTIC Index (Aller and others, 1985). The DRASTIC Index is an empirical model used to estimate the ground-water contamination potential for any hydrogeologic setting in the United States. Based on this index, appendix figure 1 indicates cropland areas where ground water is estimated to be most vulnerable to contamination from agrichemicals.

Regardless of the source of nitrogen applied, the highly mobile nitrate ion is the form which receives the most attention in terms of leaching to ground water. In contrast, the wide variety of pesticides currently being used and the differences in the chemical properties of these compounds requires a different approach to estimating leaching potential. To account for these differences, estimates of pesticide leaching potential were based on a methodology developed by the Soil Conservation Service at USDA (Goss, 1989).

The 10 production regions were disaggregated by major land resource area (MLRA). Each MLRA was then subdivided into eight land groups, representing combinations of land capability class and subclass, with the national

Appendix figure 1 -- Cropland areas where hydrogeologic conditions may promote the leaching of agricultural chemicals



resources inventory (NRI) used to determine the distribution of cropland within each land group.

The crop mix within each MLRA was assumed to be the same across all land groups. A representative soil was assigned to each land group within each MLRA and was ordinarily ranked on the basis of the potential for pesticide loss from leaching, with the determinations based on hydrologic soil group, surface horizon thickness, and the organic matter content of the surface horizon. Individual pesticides were similarly ranked according to their leachability, using an index proposed by Gustafson (1989). The index is based on two commonly reported pesticide properties: half-life in soil, and the partition coefficient between soil organic carbon and water.

Based on these soil and pesticide rankings, the model simply determines for each crop the pesticide used in each pesticide leachability category and allocates this use among the representative soils in the MLRA (app. fig. 2). Each of the three leaching potential categories shown in appendix figure 2 represents nothing more than an indicator of the relative probability of pesticide loss by leaching. The estimated changes in pesticide leaching potential reported throughout the analysis reflect only the changes observed in the Potential 1 category. This category indicates that, given the combination of soil and pesticide characteristics, the probability of

pesticide leaching is high. The Potential 2 category represents a grey area, where the probability of leaching is uncertain. The Potential 3 category estimates the risk of leaching to be low.

The estimated changes in crop acreage resulting from the implementation of each policy option were allocated across counties by a model algorithm, with each county's relative share of cropland determined by the initial 1987 calibration. The resulting changes in pesticide and nitrogen leaching potential therefore reflect the changes in chemical use associated with the predicted adjustments in regional crop mix, and the relative vulnerability of each region to ground—water quality problems as captured by the soil and pesticide partitioning shown in appendix figure 2. Appendix table 1 presents an ordinal ranking of regional vulnerability. Leaching potential per acre for both pesticides and nitrogen fertilizer is estimated to be highest in the Southeast and Appalachian regions, respectively. Due to the differences in the way nitrogen and pesticide leaching potential were calculated, these two columns in appendix table 1 should be considered independently.

The results of the three planting flexibility scenarios, shown in appendix table 2, provide an excellent example of how changes in acreage and crop mix affect the leaching potential of a region, and how these effects vary across all regions. In the Southeast, the F100A scenario (see app. table 2) results in a 0.6-percent drop in total acreage and a 2.2-percent adjustment in crop mix toward the nonprogram crops (soybeans and hay). These production shifts result in a reduction in nitrogen leaching potential, due to the relatively small nitrogen input requirements for soybeans. In contrast, pesticide leaching potential is predicted to increase. This increase is due to the relatively high use of leachable pesticides associated with soybean production in this region.

These relationships can also be seen in the Mountain region. Total acreage under the F100G scenario drops by 5 percent from large reductions in wheat and barley. Corn acreage increases, however, in response to higher corn prices and the relative profitability of corn in this region. Together, these shifts result in a positive crop mix adjustment away from feed grain crops and a decrease in nitrogen leaching potential. Pesticide leaching potential increases due to the increased use of leachable pesticides resulting from the additional corn production.

The original intent of the ground-water quality component of this analysis was to provide a mechanism for predicting the potential effects of agricultural policy on ground-water quality at the national and regional level. While this methodology does represent a significant improvement in terms of integrating the important environmental and human factors into the evaluation, it is also important to note the limitations. First, estimates of the aggregate change in agrichemical use resulting from shifts in production do not reflect the possible adjustments in chemical use rates which may accompany the adoption of crop rotations or alternative technologies. Also, the results do not consider the potential health risks associated with exposure to agrichemical residues in ground water. An estimated increase in the leaching potential for a region merely suggests that the physical properties of the agrichemicals being applied, combined with the prevailing hydrogeologic conditions, may increase the likelihood of leaching. It does not imply an increased health risk to those individuals that rely on ground water in the region.

Appendix figure 2 -- Potential pesticide loss to leaching matrix

Soil leaching potential	Pesticide leaching potential		
	Large	Medium	Small
High	Potential 1	Potential 1	Potential 2
Intermediate	Potential 1	Potential 2	Potential 3
Nominal	Potential 2	Potential 3	Potential 3

Source: Goss, 1989.

Appendix table 1 -- Estimated regional leaching potential per harvested acre (U.S. average = 1.0)

Region	Pesticides	Nitrogen
Northeast	1.9	0.7
Appalachian	2.9	1.4
Southeast	6.7	1.7
Lake States	1.1	.8
Corn Belt	.5	1.2
Delta States	.7	1.2
N. Plains	.9	.8
S. Plains	.6	1.1
Mountain	.6	.8
Pacific	.1	1.1

Appendix table 2 -- Estimated regional effects of planting flexibility on acreage, crop mix, and pesticide and nitrogen leaching potential

Region	Acreage	Crop mix 1/	Leaching potential: Nitrogen	Leaching potential: Pesticides
	Percent change			
Northeast:				
F20A	(-0.3)	0	0	0.3
F100A	(-.5)	(-1.7)	3.1	3.6
F100G	(-.3)	(-2.2)	3.5	[illegible]
Appalachian:				
F20A	(-.2)	.8	(-.5)	(-.1)
F100A	(-.4)	(-2.8)	.8	(-3.7)
F100G	(-.3)	(-4.3)	1.8	(-2.1)
Southeast:				
F20A	(-.5)	0	(-.2)	0
F100A	(-.6)	2.2	(-1.8)	3.0
F100G	(-.6)	1.5	(-1.5)	3.0
Lake States:				
F20A	(-.4)	0	(-.4)	(-.1)
F100A	(-1)	(-.9)	(-1.1)	(-9.8)
F100G	(-1)	(-.8)	(-1.9)	(-10.0)
Corn Belt:				
F20A	(-.3)	.6	(-.9)	(-1.0)
F100A	(-.2)	1.6	(-3.9)	.8
F100G	0	1.7	(-3.8)	.8
Delta:				
F20A	0	(-.3)	.3	1.6
F100A	2.4	.6	3.7	23.1
F100G	3.2	.6	4.5	23.9
Northern Plains:				
F20A	0	0	0	(-.4)
F100A	(-8.1)	14.2	(-13.1)	(-16.0)
F100G	(-8.3)	13.8	(-13.2)	(-16.1)
Southern Plains:				
F20A	(-.3)	0	(-.4)	(-.3)
F100A	(-.8)	(-.9)	(-.7)	(-24.0)
F100G	(-1.5)	(-.4)	(-1.7)	(-23.3)
Mountain:				
F20A	0	.4	.4	3.6
F100A	(-4.5)	1.2	(-.9)	27.3
F100G	(-5)	1.1	(-1.7)	25.7
Pacific:				
F20A	(-.2)	0	(-.1)	(-.1)
F100A	(-2.3)	.6	(-2.6)	(-5.4)
F100G	(-3.6)	.8	(-3.7)	(-6.1)
U.S. total:				
F20A	(-.2)	.3	(-.4)	(-.1)
F100A	(-2.5)	3.4	(-3.7)	(-4.2)
F100G	(-2.7)	3.3	(-3.8)	(-4.0)

1/ Crop mix is measured as the ratio of nonprogram to program crop acreage.

Appendix 4--Wildlife Benefit Calculations

Decisions to participate in wildlife-related recreation activities represent a series of discreet choices. Individuals select from a finite set of alternatives to reach a decision about which activity they will participate in at a particular time. Binomial choice model with a 0-1 dependent variable is a particular type of discreet choice models frequently used in recreation research (Miller and Hay, 1981; Hay and McConnell, 1984; Langner, 1989).

Such a decision model is useful in analyzing potential benefits from land retirement programs such as a wetland reserve program or expansion of the CRP. A person's decision to hunt can be modeled as a two-stage decision process: first whether or not to hunt, and then given hunting, what type of game to pursue. These decisions are hypothesized to depend on a variety of socioeconomic variables and wildlife habitat availability. Since these programs increase the availability of habitat for wildlife, they are expected to have a positive effect on wildlife populations, including certain game species. If potential hunters know wildlife populations are expanding, they may have higher expectations of successful hunting. Both new entrants into the hunting population and additional hunting from existing hunters are potential sources of benefits. Only the estimated benefits derived from new hunters are reported here.

Potential Waterfowl Hunting Benefits from a Wetland Reserve

To calculate the benefits for a wetland reserve from additional waterfowl hunters, logistic regression equations were used to estimate the probability of being a hunter, and the probability of being a waterfowl hunter, given that the respondent is a hunter (Walsh and others, 1988). These equations included coefficients for habitat availability, measuring the change in the probability of participation per 1,000 acres of additional waterfowl habitat. Habitat availability coefficients for the hunting and waterfowl hunting variables were 0.00739 and 0.09163, respectively. It should be noted that the habitat availability coefficients for waterfowl hunting were an order of magnitude higher than those for small game. This suggests that the supply of wetland areas will significantly affect hunters' decisions to hunt waterfowl.

An estimate of the number of new waterfowl hunters was calculated by multiplying the probability of waterfowl hunting for each individual across regional population figures. All new entrants were assumed to hunt the regional average number of days. Hunter-days were valued using both regional estimates (Hay, 1988) and the mean value from a published literature review (Sorg and Loomis, 1984). Total waterfowl hunting benefits were then calculated in 1990 dollars as a range for each of the three wetland reserve scenarios. This procedure assumes that the generation of benefits is a linear function of the number of hunters within the range considered.

Potential Small Game Hunting Benefits from CRP Expansion

The procedure used to calculate hunting benefits for CRP expansion is almost identical to that outlined above. Small game hunters are assumed to be the primary beneficiaries of expansion of CRP grasslands. Walsh's (1988) probability of participation equations were used to predict changes in the probability of an individual's hunting participation for each 1,000 additional acres of small game habitat. Coefficients representing the probability of hunting and the probability of a hunter choosing small game hunting were used

in conjunction with regional enrollment estimates to calculate the change in the probability of individual participation by region.

The resulting figures were multiplied across regional populations to predict the number of new hunting participants. It was assumed these new entrants would hunt the regional average number of days for a small game hunter, yielding an estimate of hunter-days for additional hunters in each farm production region. Small game hunting was valued using both regional figures (Hay, 1988) and the mean value from Sorg and Loomis: $40.7 per hunter-day measured in 1984 dollars. The totals for a potential expansion were summed and the resulting figure updated to 1990 dollars. Again, linearity in the total benefit function was assumed in the range of hunting participation considered.

Ranges for these point estimates were generated by adding and subtracting the standard errors of the habitat coefficient estimates for the hunting equation to and from the coefficient itself. Since additional habitat is thought to have the greatest effect on the first stage of the decisionmaking process, the coefficient in the waterfowl hunting equation was assumed constant. To be conservative, the low-point to high-point estimates were used to define the benefit range.

Total benefits for 1990-2000 from the implementation of a 2.5- or 5-million-acre wetland reserve were calculated at between $476 million to 845 million and $916 million to 1,627 million, respectively. Benefit ranges for CRP expansion were also calculated in a similar fashion. Total benefits for a 5- and 10-million acre expansion were calculated to be $84 million to $115 million and $164 million to $225 million, respectively.

* U.S. G.P.O.:1991-281-091:40070/ERS

UNITED STATES DEPARTMENT OF AGRICULTURE
ECONOMIC RESEARCH SERVICE
WASHINGTON, DC 20005-4788